Prince Mohamed Bin Fahd University

College of Engineering

Department of Civil Engineering

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Structural & Geotechnical Design of Touristic Complex in Front of a Beach

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ABSTRACT

Liquefaction has been defined as the transformation of a granular material from a solid state into a liquefied state as a consequence of increased pore-water pressure (Perkins et al, 2001). When the ground liquefies, sandy materials saturated with water can behave like a liquid, instead of like solid ground. The ground may sink or even pull apart. Sand boils, or sand “volcanoes,” can appear (Perkins et al, 2001). Liquefaction can cause ground displacement and ground failure such as lateral spreads (essentially landslides on nearly flat ground next to seas, rivers, harbors, and drainage channels) and flows.

The aim of this project is to design a touristic complex in a difficult or problematic soil, such as liquefiable soil. The project includes the placement and repartition of the different components of the complex (such as apartment hotel units, restaurant, main access roads and cars parking areas), structural design of the different elements of the complex using an appropriate computer software (SAP2000), geotechnical investigation which include the proposed solutions for the foundation systems of the different components of the complex (such as apartment units and restaurant), and development of a complex prototype. Two types of foundation system were investigated, including shallow foundations when the area is vibro-compacted and deep foundations (i.e. driven metallic piles

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CHAPTER 1: INTRODUCTION

1.1. General

Loose sand and silt that is saturated with water can behave like a liquid when shaken by an earthquake. Earthquake waves cause water pressures to increase in the sediment and the sand grains to lose contact with each other, leading the sediment to lose strength and behave like a liquid (Geology and Soils, 2013). In general, three factors are required for liquefaction to occur: i) Loose-granular sediment, ii) Saturation of the sediment by ground water (water fills the spaces between sand and silt grains), and iii) Strong shaking. When liquefaction occurs, the ability of a soil deposit to support foundations for buildings and bridges is reduced, causing turnover (Lose of bearing capacity), Geology and Soils (2013)

Il was reported that (Quicktip – Science, 2014), once the liquefaction manifests, the following problem may arise: i) Loss of bearing strength: the ground can liquefy and lose its ability to support structures, ii) Lateral spreading: the ground can slide down very gentle slopes or toward stream banks riding on a buried liquefied layer., iii) Sand boils: sand-laden water can be ejected from a buried liquefied layer and erupt at the surface to form sand volcanoes; the surrounding ground often fractures and settles, iv) Flow failures: earth moves down steep slope with large displacement and much internal disruption of material, v) Ground oscillation: the surface layer, riding on a buried liquefied layer, is thrown back and forth by the shaking and can be severely deformed, vi) Flotation: light structures that are buried in the ground (like pipelines, sewers and nearly empty fuel tanks) can float to the surface when they are surrounded by liquefied soil, and vii) Settlement: when liquefied ground re-consolidates following an earthquake, the ground surface may settle or subside as shaking decreases and the underlying liquefied soil becomes denser (Quicktip – Science, 2014).

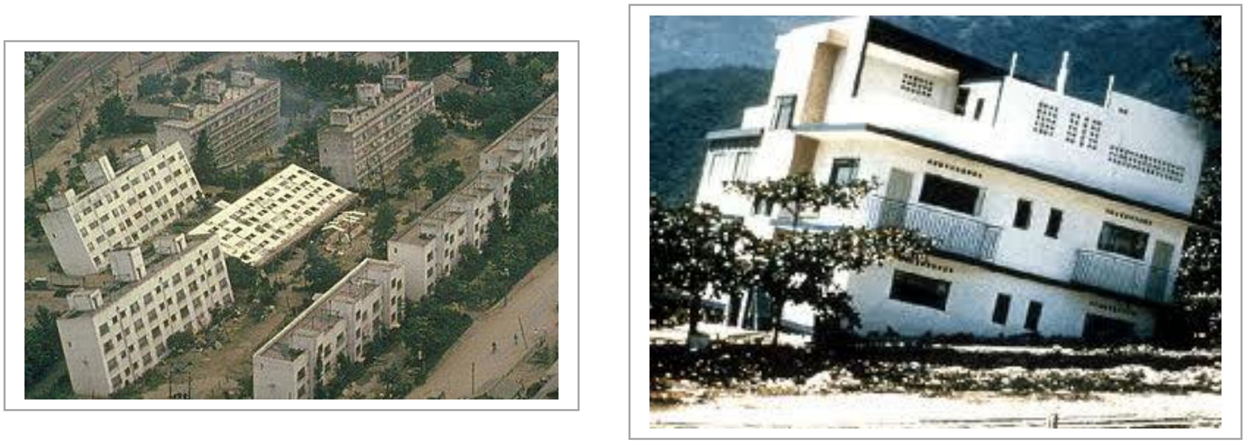


Figure 1. An example of a structure collapse failure (from internet)

The most well-known treatment methods for the liquefaction can be summarized as follows (Andrus and Chung, 1995): i) Vibrocompaction: process of densification by vibration and compaction of sandy and gravely backfill material. It is more suitable for cohesionless soil with less than 20% fines. Treatment depth: greater than 20 m, low to moderate cost, ii) Compaction piles: process of densification by vibration during piles driving of loose sandy soil, partly saturated. Treatment depth: greater than 20 m, moderate to high cost, iii) Dynamic compaction: process of repeated heavy damping at surface of cohesionless soil. Treatment depth: may be more than 20 m, low cost, iv) Drains: process of dissipation of pore water pressure in sand, silt or clay. Treatment depth: greater than 30 m (for gravel and sand), moderate to high cost, v) Grouting: process of injection and mixing of a stabilizer with soil (e.g. cement, lime) could be applied on sand, silts and clays, and vi) Vibro-replacement: process of jetting cylindrical holes into a soil and backfilled with densely compacted gravel. This technique is suitable for sand, silts and clays (treatment depth is about 30 m and its cost is moderate).

1.2. Project Objectives

The main objectives of this project are to design a series of hotel-apartments and a two floor restaurant to be constructed near to a sea beach where the soils are granular and saturated (i.e. susceptible to liquefaction). Moreover, the level of the water table in this case is almost on the surface. The project includes structural and geotechnical design of a hotel-apartment prototype and the restaurant, and the pavement design of local roads & parking.

The project is composed by the following stages or parts:

1- Development of the different architectural plans of the hotel apartments (including top and side views plans, and perspectives plans).
2- Structural design of a hotel-apartment unit (prototype) and the restaurant.
3- Geotechnical design of the different foundation system: foundations on vibro-compacted soil and piles.
4- Pavement design of a road & parking sections (prototype sections).
5- Development of the hotel-apartment prototype.

1.3. Scope of the report

The present report is composed of six chapters. A detailed description of the project and its components (i.e. hotel-apartment units, restaurants, and parking & access roads) is presented in chapter 2. Soil report is introduced in chapter 3 including site investigation, laboratory works and soil profile. Following that, the structural and geotechnical design of the different elements of the hotel-apartment are given in chapters 4 and 5, respectively. The report is achieved by some specific and general conclusions.

CHAPTER 2: Description of the project

2.1 Introduction

This chapter is mainly concerned by the description of the overall components or parts of the touristic complex. The complex is constituted by many apartment hotels buildings and some related facilities. It is composed mainly by two different types of buildings, including: four stories apartment hotels units and two big restaurants. Moreover, the complex is surrounded by many car parking and two main roads.

The chapter will start by describing the overall component of the complex (i.e. the different parts of the complex). Then a description is given concerning the apartment hotel units (including the architecture disposition and their repartition). Following that a brief description of the restaurants is included. Finally, the chapter is achieved by some information concerning the different cars parking and the access roads.

2.2 overall description of the project

The site of the complex extends over an area of about 70000 m^2 (i.e. 650m $\times$105m) and is located fictively in Al-Azizia in the eastern province of the Kingdom of Saudi Arabia. The complex is delimited by two different streets. One main street located on the front of the hotel units and parallel to the beach, and another secondary street, situated in the middle of the complex, and divides it to two identical parts.

The following parts compose the Project:

- Twelve apartment hotel units constructed parallel to each other, six units in each side of the secondary street (Figures 2.1 to 2.3). Each unit is composed of four stories, including the ground level which accommodates three shops.

- A two-floor restaurant designed to accommodate two sections; family and single sections. Each restaurant has its own parking which is planned to accommodate a big number of cars (Figure 2.4).
- Two different roads (main and secondary roads) and many cars parking are planned to be in the back of each hotel unit.

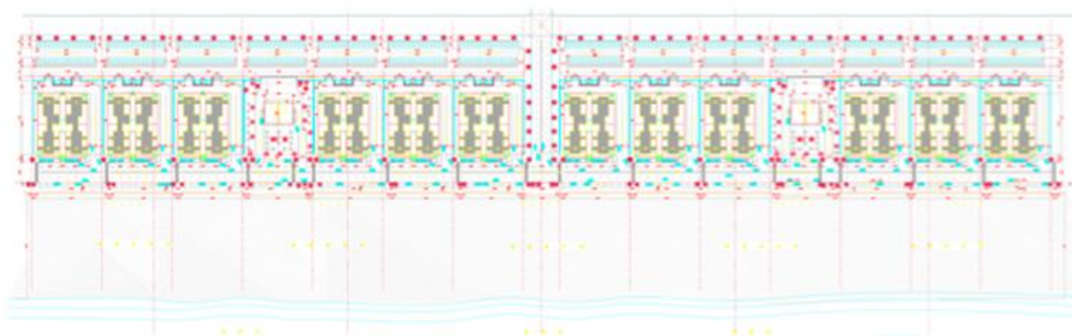


Figure 2.1. Plan view of the complex

Figure 2.2. Overview of the complex (photo 1)

Figure 2.3. Overview of the complex (photo 2)

Figure 2.4. Overview of the restaurant

2.3 Apartment units

As mentioned previously, twelve similar apartment hotel units are designed in this project . The plan area of each apartment unit will be around 192 m^2 (i.e. 12m × 16m). The units will be placed parallel to each other. Around the units some trees and small green areas will be implanted to give a nice view of the area.

The units are composed of three floors (i.e. stories), including the ground floor. The ground floor accommodates three different shops and a car parking area for customers. The parking garage has one main entrance communicating to the outside and one other door which communicate to the inside building. The first three stories above the ground floor are designed as apartments. Each story is composed of four similar apartments (i.e. apartments having the same plan area and number of rooms). However, the last story is divided into two apartments. There will be an emergency exit and an elevator for each building (Figures 2.5 and 2.6).

Each apartment is constituted of three different rooms, a kitchen and bathrooms. The rooms have almost the same size with an average area of about 9 m^2 (3m×3m). However, the apartments of the last floor, having a plan area of 6 m^2, are divided into four rooms, a kitchen and bathrooms.

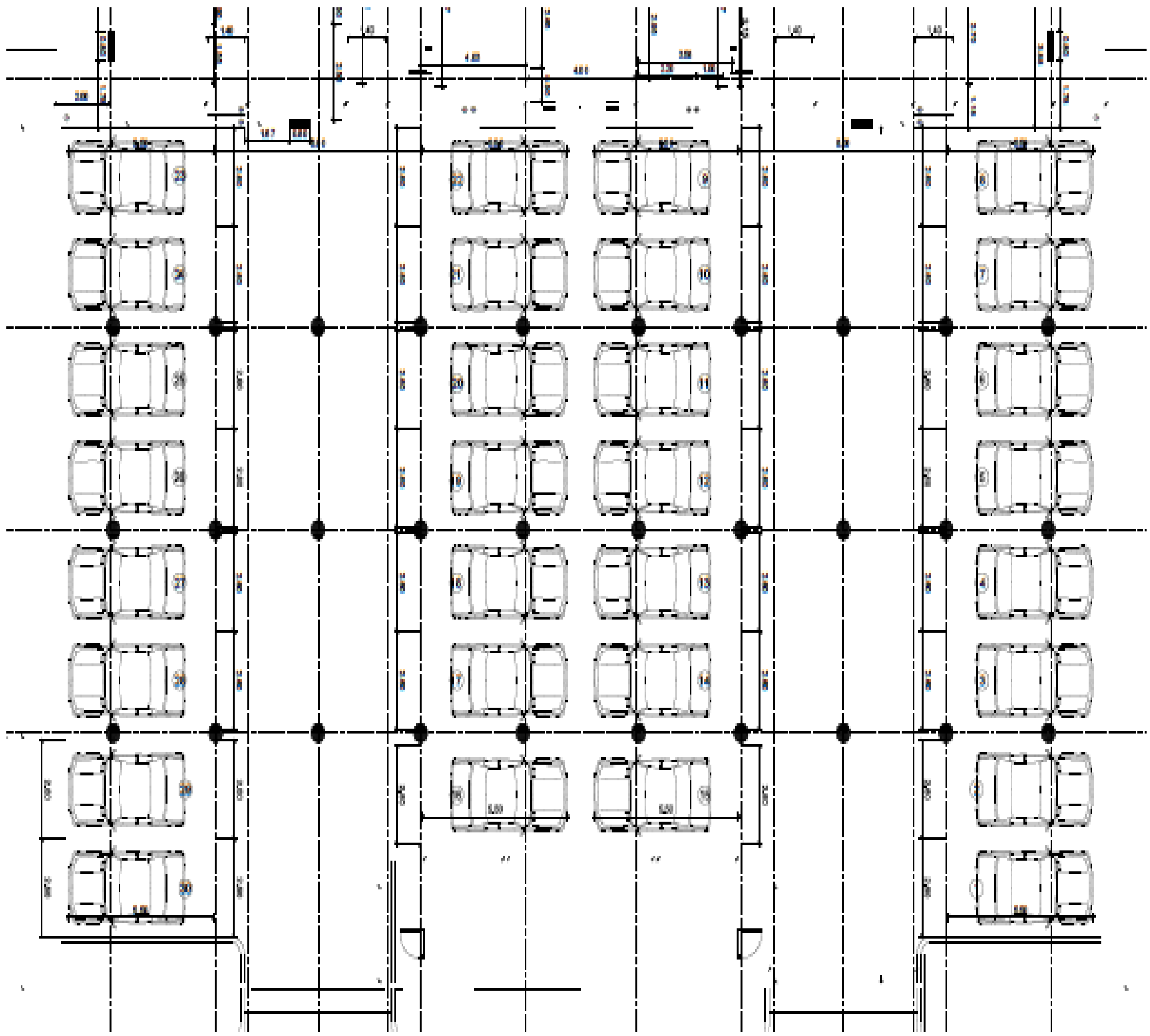


Figure 2.5. Plan of the ground floor (parking garage)

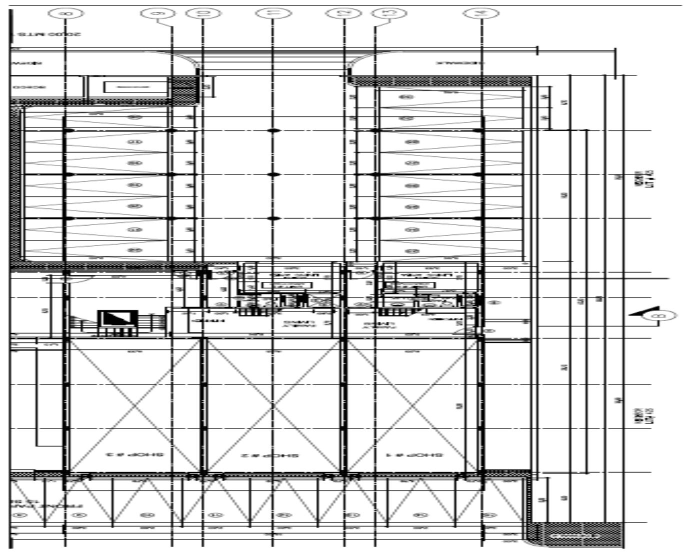


Figure 2.6. Plan of the Ground floor

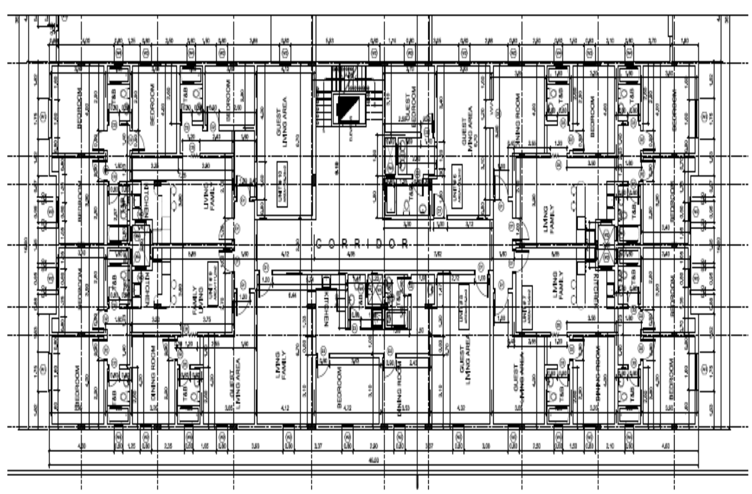


Figure 2.7. Plan of the 1$^{s \text{ and } 2nd}$

2.4 Structure of the Restaurant

Two restaurants are planned for the complex. Each restaurant is located in the middle of half part of the complex. It is composed of two floors or stories and it has an average area of about

1900 m^2 (i.e. 44m ×44m). The shape of the Restaurant, in top view, is in the form of three parallel lines. The Restaurant is provided with one main entrance and an emergency exit located in the back of the building. The height of the building is around 10 m. The main parts of the restaurant are a family and single sections, and two offices of the manger. Moreover, a smoking area and children play area are also included (Figures 2.7 and 2.8).

The restaurant is provided will many washrooms and bathrooms situated in the ground floor of the building. An elevator is also designed in the restaurant. The building has a nice view since all its sides will be covered by glass.

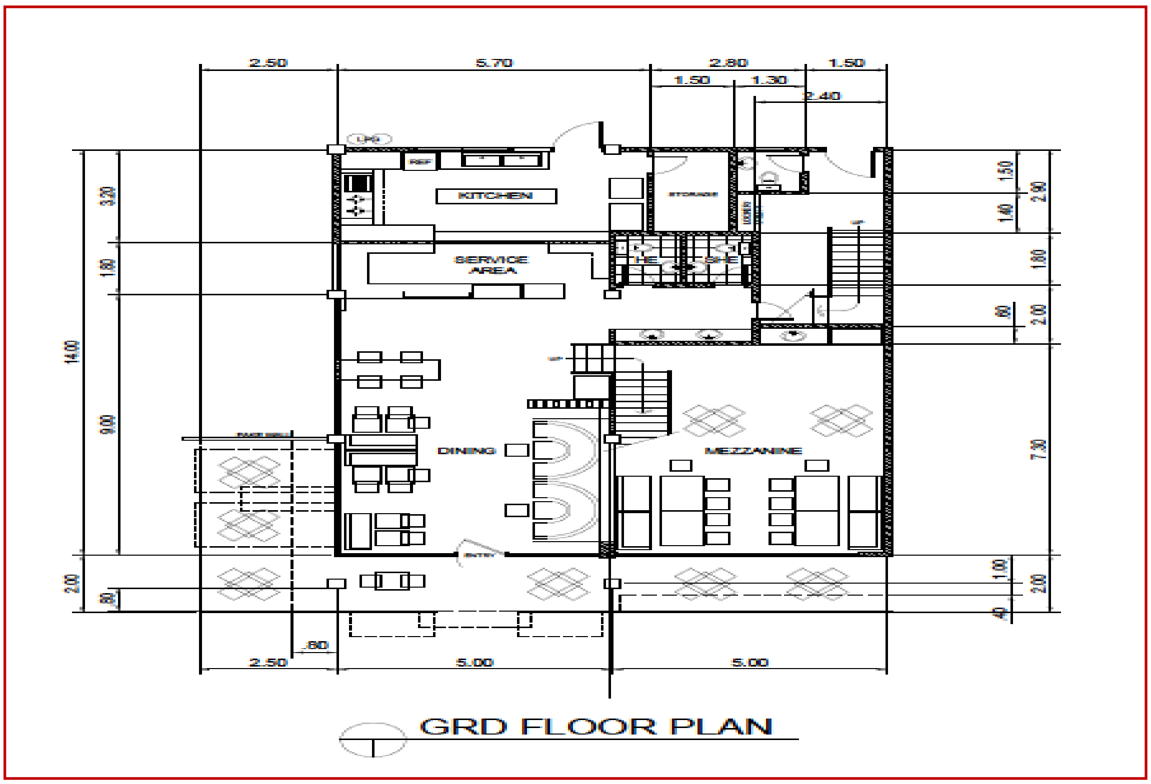


Figure 2.8. Plan of the ground floor of the restaurant

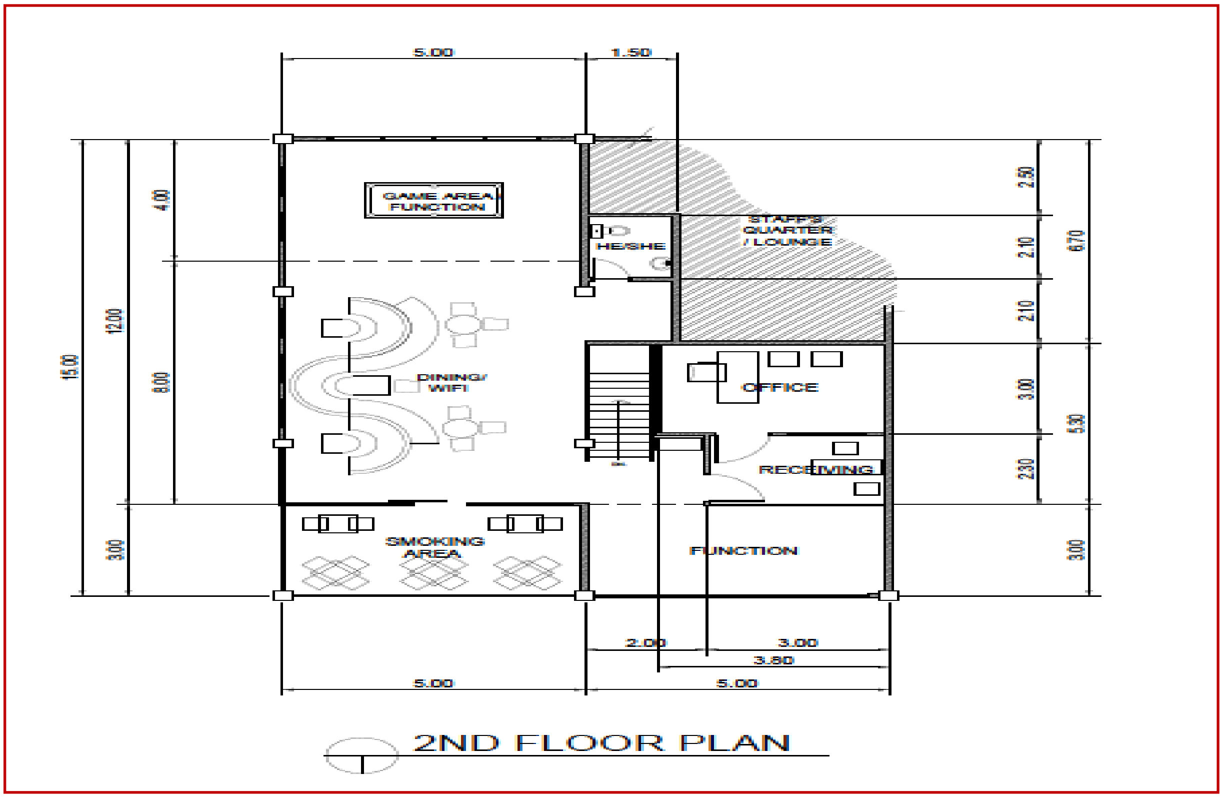


Figure 2.9. Plan of the 2nd floor of the restaurant.

2.5 Parking and access roads

The road network of the complex is composed by main and secondary access roads. The main road is about 700 m long and it has a width of 4×4 meters (two lines in each direction). The road is provided with two sidewalks and equipped in its middle by a path design to accommodate some trees and standard and floor lamps. In the side of the units and along the complex some car parking areas are designed. Moreover, a secondary road (located in the middle of the complex) is designed to have a width of 2×4 meters. The road is equipped with appropriate traffic signs, including signs considering children/old people mobility (Figure 2.9).

The complex is surrounded by much cars parking area. The cars parking areas are distributed uniformly all around the compound, including the in the front of the buildings. Furthermore, two bus stops were provided in the front of the habitation area (Figure 2.10).

Figure 2.10. Location of the main and secondary roads

Figure 2.11. Location of the different car parking areas

Chapter 3 : Soil Report

3.1 Introduction

Loose sand and silt that is saturated with water can behave like a liquid when shaken by an earthquake. Earthquake waves cause water pressures to increase in the sediment and the sand grains to lose contact with each other, leading the sediment to lose strength and behave like a liquid. Therefore, three factors are required for liquefaction to occur: i)- Loose-granular sediment, ii)- Saturation of the sediment by ground water (water fills the spaces between sand and silt grains), and iii)- Strong shaking. When liquefaction occurs, the ability of a soil deposit to support foundations for buildings and bridges is reduced, causing turnover (Lose of bearing capacity)

This chapter is concerned by the description of the site and laboratory investigations, soil report and ground profile of the site of the compound. The information obtained in these investigations is used to design the foundation systems for the apartments hotel units and the restaurants.

3.2 Site Investigation

A geotechnical investigation was carried out by the company LandMark Geo-Engineers and Geologists in a site similar to the site of the actual project. The purpose of the geotechnical study was to investigate the upper 50 feet of subsurface soil at selected location within the site for evaluation of physical and engineering properties. From study of field and laboratory data, professional opinions were developed and are provided in this report regarding geotechnical conditions at this site and the effect on design and construction.

The scope of the geotechnical investigation consisted of the following:

- Field exploration and in-situ testing of the site soils at selected locations and depths.
- Laboratory testing for physical and /or chemical properties of selected samples.
- Engineering analysis and evaluation of the data collected.

- Recommendations for the geotechnical aspects of the project design and construction.

A report was addressed by LandMark Geo-Engineers and Geologists and it addresses the following geotechnical issues:

- Subsurface soil and groundwater conditions,
- Liquefaction potential and its mitigation,
- Expansive soil if any and methods of mitigation,
- Aggressive soil conditions to metals concrete, if any.

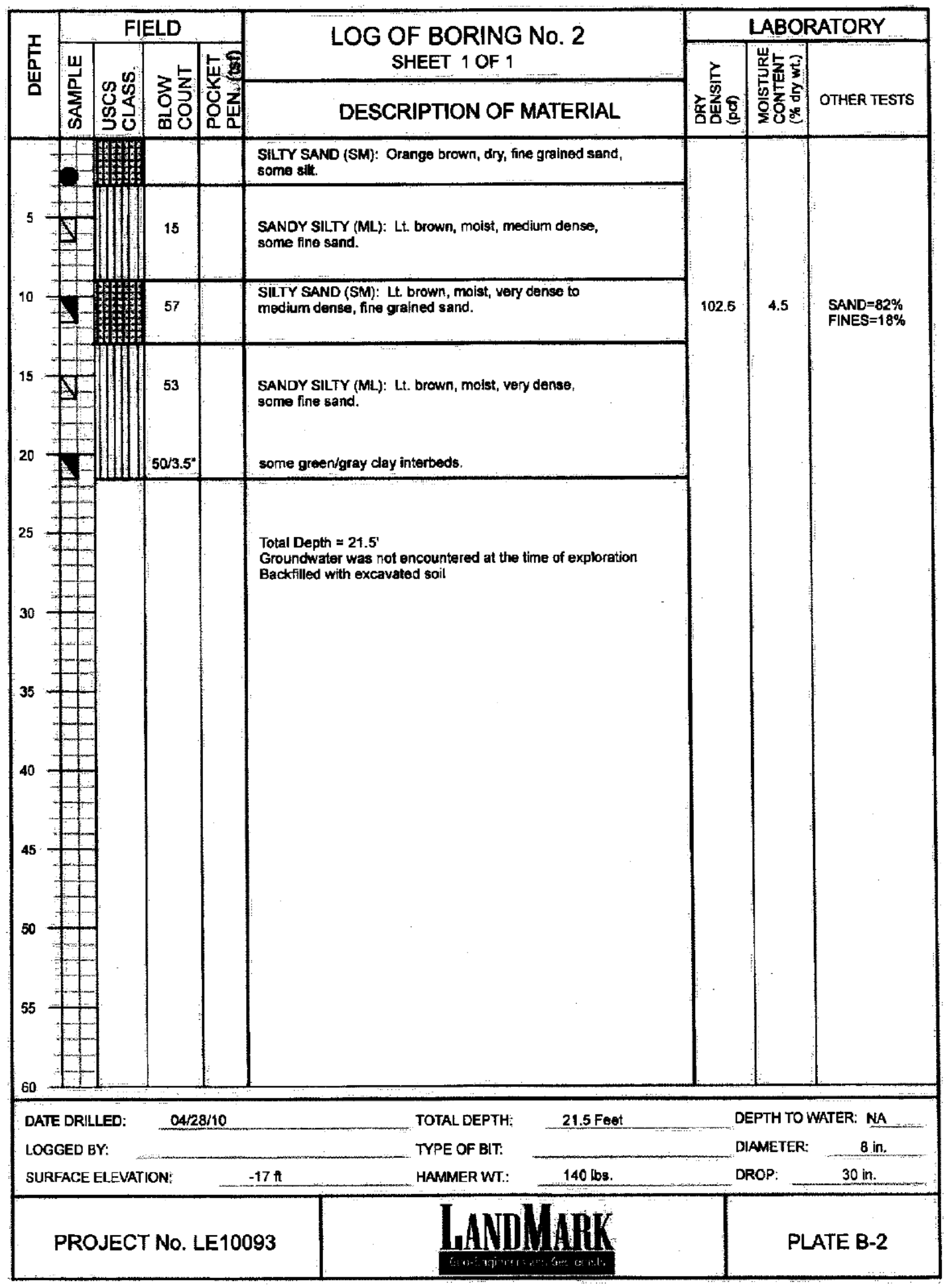
In the following section it is believed that it is worthy to report some information from the report addressed by the company LandMark Geo-Engineers and Geologists (i.e. the following information was reproduced from the report of LandMark Geo-Engineers and Geologists.

3.2.1 Field Exploration

Subsurface exploration was performed on April 28 and 29, 2010 using 2R Drilling of Ontario California to advance fifteen (15) borings to depths of 20 to 50 feet below existing ground surface. The borings were advanced with a truck-mounted, CME 55 drill rig using 8-inch diameter, hollow stem, and continuous-flight augers.

A professional engineer observed the drilling operations and maintained logs of the soil encountered with sampling depths. During drilling soils were visually classified according to the Unified Soil Classification System and relatively undisturbed and bulk samples of the subsurface materials were obtained at selected intervals. The relatively undisturbed soil samples were retrieved using a 2-inch outside diameter (OD) split-spoon sampler or a 3-inch OD Modified California Split-Barrel (ring) sampler. In addition, Standard Penetration Tests (SPT) was performed in accordance with ASTM D1586. The samples were obtained by driving the samplers ahead of the auger tip at selected depths using a 140-pound CME automatic hammer with a 30-inch drop. The number of blows required to drive the samplers the last 12 inches of an 18-inch drive depth into the soil is recorded on the boring logs as "blows per foot". Blow counts (N values) reported on the boring logs represent the field blow counts. No corrections have been applied for effects of overburden pressure, automatic hammer drive energy, drill rod lengths, liners, and sampler diameter. Pocket electrometer readings were also obtained to evaluate the stiffness of cohesive soils retrieved from sampler barrels.

Some examples of the subsurface logs are presented herein below. The stratification lines shown on the subsurface logs represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth.



DEPTH	FIELD: SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)	LOG OF BORING No. 2 SHEET 1 OF 1 — DESCRIPTION OF MATERIAL	LABORATORY: DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)	OTHER TESTS
					SILTY SAND (SM): Orange brown, dry, fine grained sand, some silt.			
5			15		SANDY SILTY (ML): Lt. brown, moist, medium dense, some fine sand.			
10			57		SILTY SAND (SM): Lt. brown, moist, very dense to medium dense, fine grained sand.	102.6	4.5	SAND=82% FINES=18%
15			53		SANDY SILTY (ML): Lt. brown, moist, very dense, some fine sand.			
20			50/3.5"		some green/gray clay interbeds.			
25					Total Depth = 21.5' Groundwater was not encountered at the time of exploration Backfilled with excavated soil			
30								
35								
40								
45								
50								
55								
60								

DATE DRILLED: 04/28/10 TOTAL DEPTH: 21.5 Feet DEPTH TO WATER: NA
LOGGED BY: TYPE OF BIT: DIAMETER: 8 in.
SURFACE ELEVATION: -17 ft HAMMER WT.: 140 lbs. DROP: 30 in.

PROJECT No. LE10093 LANDMARK PLATE B-2

Figure 3.1(*a*). Example #1 of the results of borehole (Plate B-2) (from Land Mark Company)

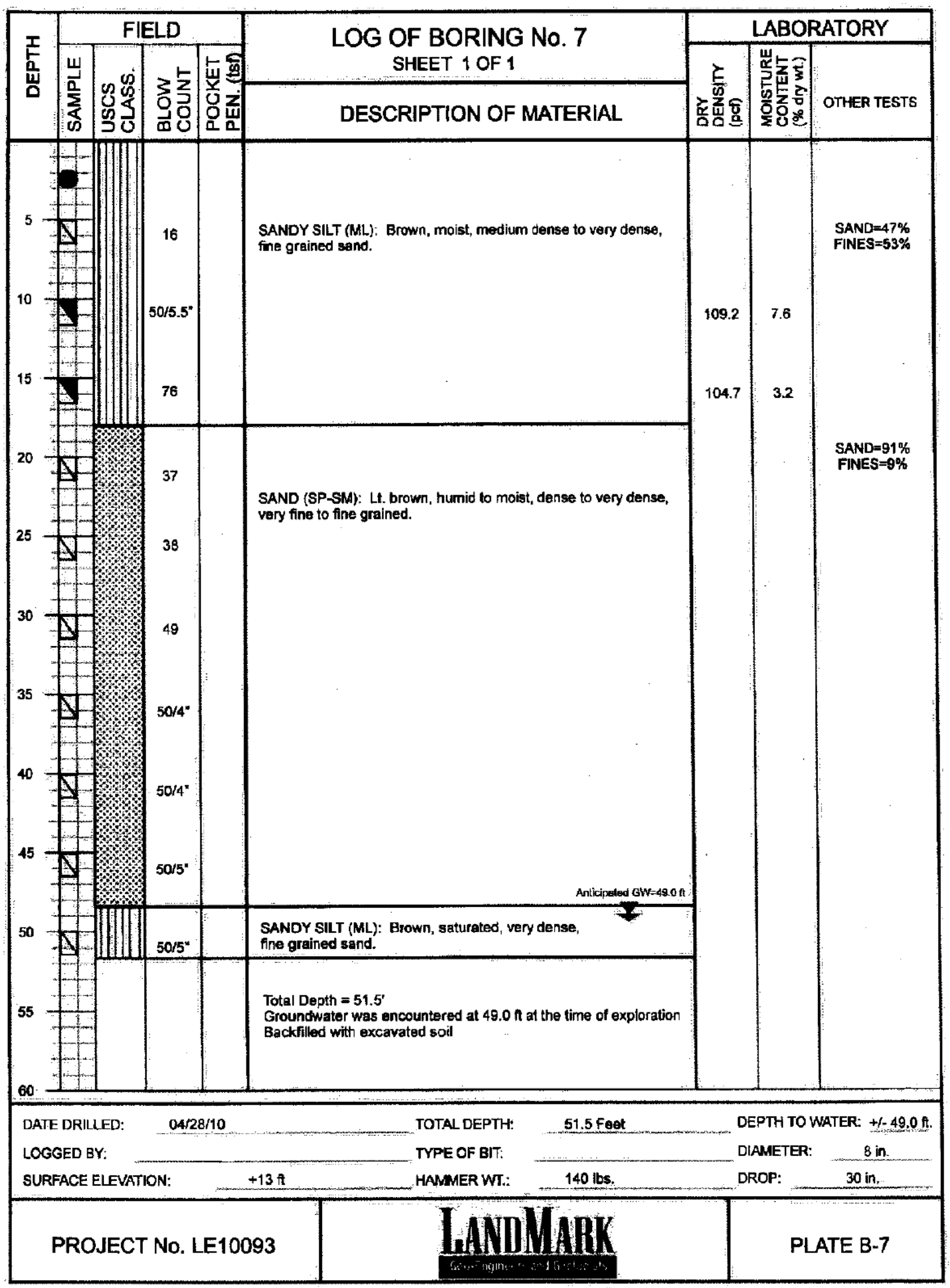


Figure 3.1(*b*). Example #2 of the results of borehole (Plate B-7) (from Land Mark Company)

LOG OF BORING No. 12

SHEET 1 OF 1

DEPTH	FIELD: SAMPLE	FIELD: USCS CLASS.	FIELD: BLOW COUNT	FIELD: POCKET PEN. (tsf)	DESCRIPTION OF MATERIAL	LABORATORY: DRY DENSITY (pcf)	LABORATORY: MOISTURE CONTENT (% dry wt.)	LABORATORY: OTHER TESTS
					SILTY SAND (SM): Lt. brown, dry, very fine grained.			
5			13	4.5	SILTY CLAY (CL): Reddish brown, moist, hard, high plasticity.			LL=39% PI=22%
10			64		SILTY SAND (SM): Lt. brown, dry to humid, very dense to medium dense, very fine grained.			
15			69			101.8	2.7	SAND=80% FINES=20%
20			27		medium dense, moist			
25					Total Depth = 21.5' Groundwater was not encountered at the time of exploration Backfilled with excavated soil			
30								
35								
40								
45								
50								
55								
60								

DATE DRILLED:	04/28/10	TOTAL DEPTH:	21.5 Feet	DEPTH TO WATER:	NA
LOGGED BY:		TYPE OF BIT:		DIAMETER:	8 in.
SURFACE ELEVATION:	0 ft	HAMMER WT.:	140 lbs.	DROP:	30 in.

PROJECT No. LE10093 | LANDMARK | PLATE B-12

Figure 3.1(*c*). Example #3 of the results of borehole (Plate B-12(from Land Mark Company)

3.2.2 Laboratory Testing

Laboratory tests were conducted on selected bulk (auger cuttings) and relatively undisturbed soil samples obtained from the soil boring to aid in classification and evaluation of selected engineering properties of the site soils. The tests were conducted in general conformance to procedures of the American Society for Testing and Materials (ASTM) or other standardized methods as referenced below. The laboratory-testing program consisted of the following tests:

- Plasticity index (ASTM D4 318) – used for soil clarification
- Particle size Analyses (ASTM D 422) – used for soil classification and liquefaction evaluation.
- Unit dry Densities (ASTM D2937) and Moisture Contents (ASTM D2216)- used for inset soil parameters.
- Direct shear (ASTM D3080) –used for soil strength determination
- Unconfined Compression (ASTM D2166) – used for soil strength estimates
- Chemical Analyses (soluble sulfates & chlorides, pH and resistivity) (Caltrans Methods) –used for concrete mix proportions and corrosion protection requirements.

Some of the results of the laboratory test results are presented on the subsurface logs and summarized in the following section:

3.3 Site Conditions

The project site is located near a beach in an active area from a seismology point of view. The project site lies at elevation of approximately 4 feet above to 2 feet below mean sea level. The surrounding properties lie on terrain, which is flat (planar). Annual rainfall in this semi-arid region is less than 3 inches per year with eight months of average summertime temperatures above 35 C^{o}. Winter temperatures are mild, seldom reaching freezing during the night.

The project site is located in the seismically active area and is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. The proposed site structures should be designed in accordance with the Saudi Building Code for ‘Maximum Considered Earthquake’ (MCE) and with the appropriate site coefficients. The MCE is defined as the ground motion having a 2 percent probability.

The primary seismic hazard at the project site is the potential for strong ground shaking during earthquakes along the border of the sea. The project site does not lie within an Earthquake Fault Zone. Surface fault rupture is considered to be unlikely at the project site because of the Well-delineated fault lines through the border sea. However, liquefaction is a potential design consideration because of underlying saturated sandy substrata. The potential for liquefaction at the site is discussed in more detail in the following sections. The hazard of land sliding is unlikely due to the regional planar topography. No ancient landslides are shown on geologic maps of the region and no indications of landslides were observed during our site ingratiation. The site is not located in proximity to any known volcanically active area and the risk of volcanic hazards is considered very low.

Subsurface soils encountered during the field exploration conducted on April 28 and 29, 2010 consist of dominantly of silty sands with interbedded silts and clays in the northwestern portion of the site and interbedded clays and sands in the southeastern portion of the site. The examples of the subsurface logs (Figures 4.1*a* to *c*) depict the stratigraphic relationships of the various soil types.

Development of building foundations, concrete flatwork, and asphaltic concrete pavements should include provisions for mitigation reduction in soil strength, which can occur from saturation of the soil. Causes for soil saturation include landscape irrigation, broken utility lines, or capillary rise in moisture upon sealing the ground surface to evaporation. Moisture losses can occur with lack of landscape watering, close proximity of structures to downslopes and root system moisture extraction from deep rooted shrubs and trees placed near the foundations. Groundwater encountered in the borings ranged in depth from about 1 to 2 feet during the time of exploration.

Liquefaction occurs when granular soil below the water table is subjected to vibratory motions, such as produced by earthquakes. With strong ground shaking, an increase in pore water pressure develops as the soil tends to reduce in volume. If the increase in pore water pressure is sufficient to reduce the vertical effective stress (suspending the soil particles in water), the soil strength decreases and the soil behaves as a liquid (similar to quicksand). Liquefaction can produce excessive settlement, ground rupture, lateral spreading, or failure of shallow bearing foundations.

As stated previously, four conditions are generally required for liquefaction to occur:

1. The soil must be saturated (relatively shallow groundwater);
2. The soil must be loosely packed (low to medium relative density);
3. The soil must be relatively cohesionless (not clayey); and
4. Groundshaking of sufficient intensity must occur to function as a trigger mechanism.

All of these conditions exist to some degree at this site. Liquefaction potential at the project site was evaluated using the 1997 NCEER Liquefaction Workshop methods. The 1997 NCEER methods utilize direct SPT blow counts or CPT cone readings from site exploration and earthquake magnitude PGA estimates from the seismic hazard analysis.

3.4 Relevant Recommandations

1- Shallow spread footings are suitable to support the new apartments hotel units and the restaurants because the ground is adequately compacted. Footings shall be founded on compacted building support fill soils. All exterior footings should be embedded a minimum of 18 inches below the building support pad or lowest adjacent final grade, whichever is deeper. Embedment depth of interior footings should be a minimum of 12 inches deep. Interior footing embedment depths shall be determined by the structural engineer/designer and should be sufficient to limit differential movement to 1.0 inch or less. The footings should have a minimum dimension of 24 inches and should be structurally tied to perimeter footings or grade beams. Recommended concrete reinforcement and sizing for all footings should be provided by the structural engineer.

2- The use of driven steel piles requires special provisions for corrosion protection due to the corrosive nature of the subsurface soils. Precast, priestesses concrete piles are often used in the corrosive soil environments of the site. Selection of pile type may be based on drivability and cost comparisons. Total settlements of less than 1 inch, and differential movement of about two-thirds of total movement for single piles designed according to the preceding recommendations. If pile spacing is at least 2.5 pile diameters center-to center, no reduction in axial load capacity is considered necessary for a group effect.

3- Concrete floor slabs shall be monolithically placed with the footings (no cold joints). The concrete slabs should be underlain by a lO-mil polyethylene vapor retarder that works as a capillary break to reduce moisture migration into the slab section. The vapor retarder should be properly lapped and continuously sealed and extend a minimum of 12 inches into the footing excavations. The vapor retarder should be overlain by 2 inches of clean sand (Sand Equivalent SE>30). Concrete slabs may be placed without a sand cover directly over a 15-mil vapor retarder (Stego-Wrap or equivalent). Concrete slab and flatwork reinforcement should consist of chaired rebar slab reinforcement (minimum of No. 3 bars at 18-inch centers, both horizontal directions) placed at slab mid-height to resist potential cracking. Slab thickness and steel reinforcement are minimums only and should be verified by the structural engineer/designer knowing the actual project loadings. All steel components of the foundation system should be protected from corrosion by maintaining a 3-inch minimum concrete cover of densely consolidated concrete at footings (by use of a vibrator). The construction joint between the foundation and any mowstrips/sidewalks placed adjacent to foundations should be sealed with a polyurethane based non-hardening sealant to prevent moisture migration between the joint.

4- Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the Project site The native sand soils were found to have low levels of sulfate ion concentration. Sulfate ions in high concentrations can attack the cementitious material in concrete, causing weakening of the cement matrix and eventual deterioration by raveling.

5- Pavements should be designed according to AASHTO or other acceptable methods. Traffic indices were not provided by the project engineer or owner. The public agency or design engineer should decide the appropriate traffic index for the site. Maintenance of proper drainage is necessary to prolong the service life of the pavements. The site is dominated by surficial sands. Pavement structural section is provided for such soil.

CHAPTER 4: STRUCTURE DESIGN

4.1 Introduction

This chapter covers the structural design of the different habitation elements of the project. A computer program namely SAP2000 (Structural Analysis Program 2000) is used for this purpose. The design will be performed in the following order: apartment units and then the restaurant. The design is concerned mainly by determining the appropriate steel reinforcements for the different concrete elements and the solicitations which will be transmitted to the foundation systems.

4.2 Apartment Units

As indicated in chapter 2, the apartment units are composed of four floors or stories. Each unit will cover an area around 192 m^2 (i.e. 12m × 16m). The dead and live load considered for the design area were taken from the Saudi Building Code (SBC). The live load is taken to be 5 KN/m^2. However, a factor of safety of 1.6 is applied on the live load; while, a factor of 1.2 is applied on the dead load. In addition, all safety factors are calculated automatically in SAP2000 (Figure 4.1).

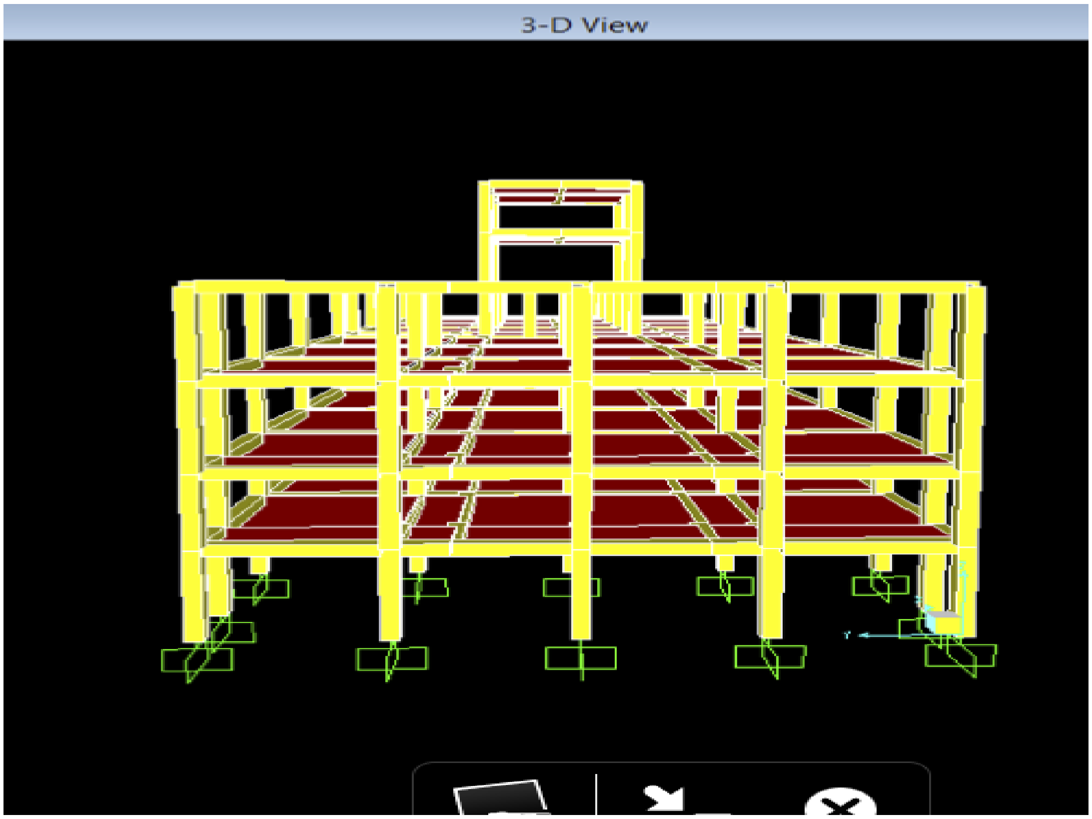


Figure 4.1: Design of apartment unit (SAP2000).

All columns are considered to be connected (from the ground to the thread floor). The following data are used in the SAP design: i)- the columns are identical and have a cross section of 80 cm×30 cm, ii)- 3 #9 are considered in the longest side and 3 #9 in the shorter side, iii)- the concrete is of the type 4000 psi, iv)- the tie reinforcement is taken # 2 every 7 cm, and v)- the reinforcement of the columns is considered the same in the vertical direction from ground to third floor (Figure 4.2).

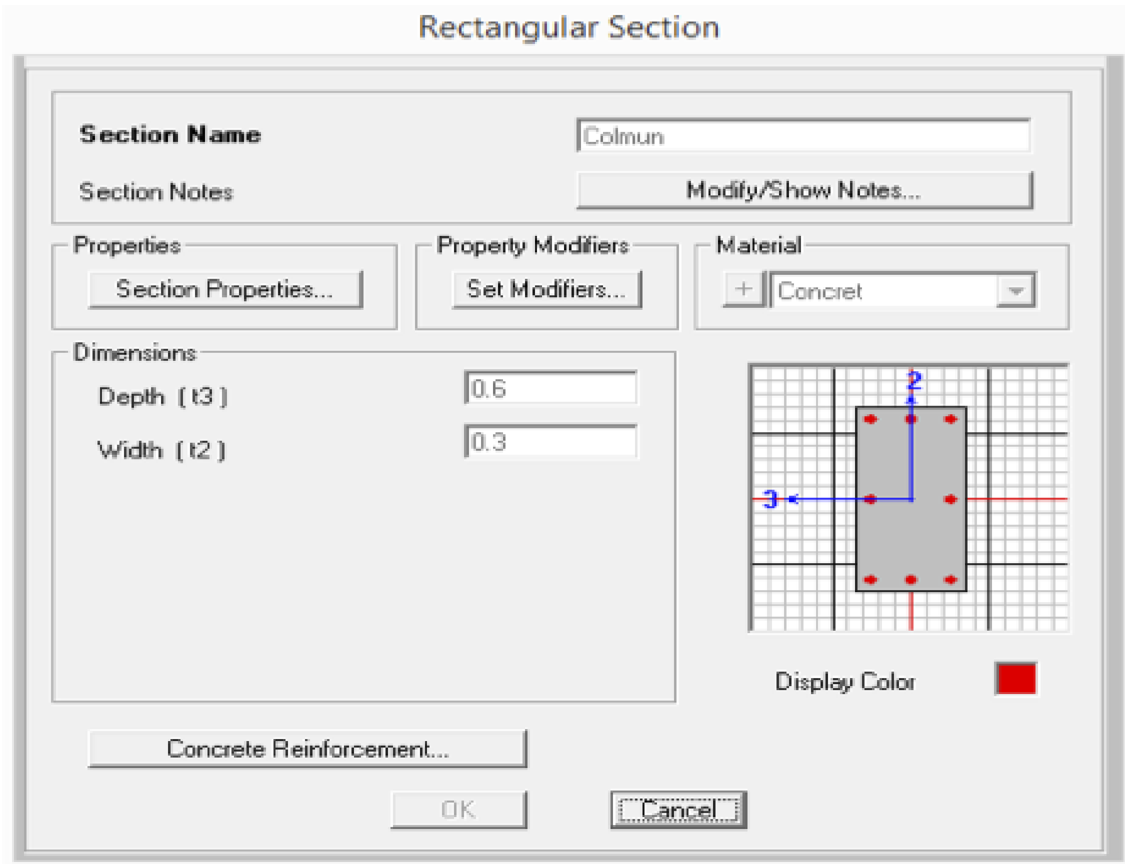


Figure 4.2: Reinforcement of the columns. (SAP2000).

All the area is designed in plane-stress with a concrete of the type 4000 psi concrete, a thickness of membrane 0.1524 cm, and the bending is 0.1524, the load is considered acting or distributed over the entire area.

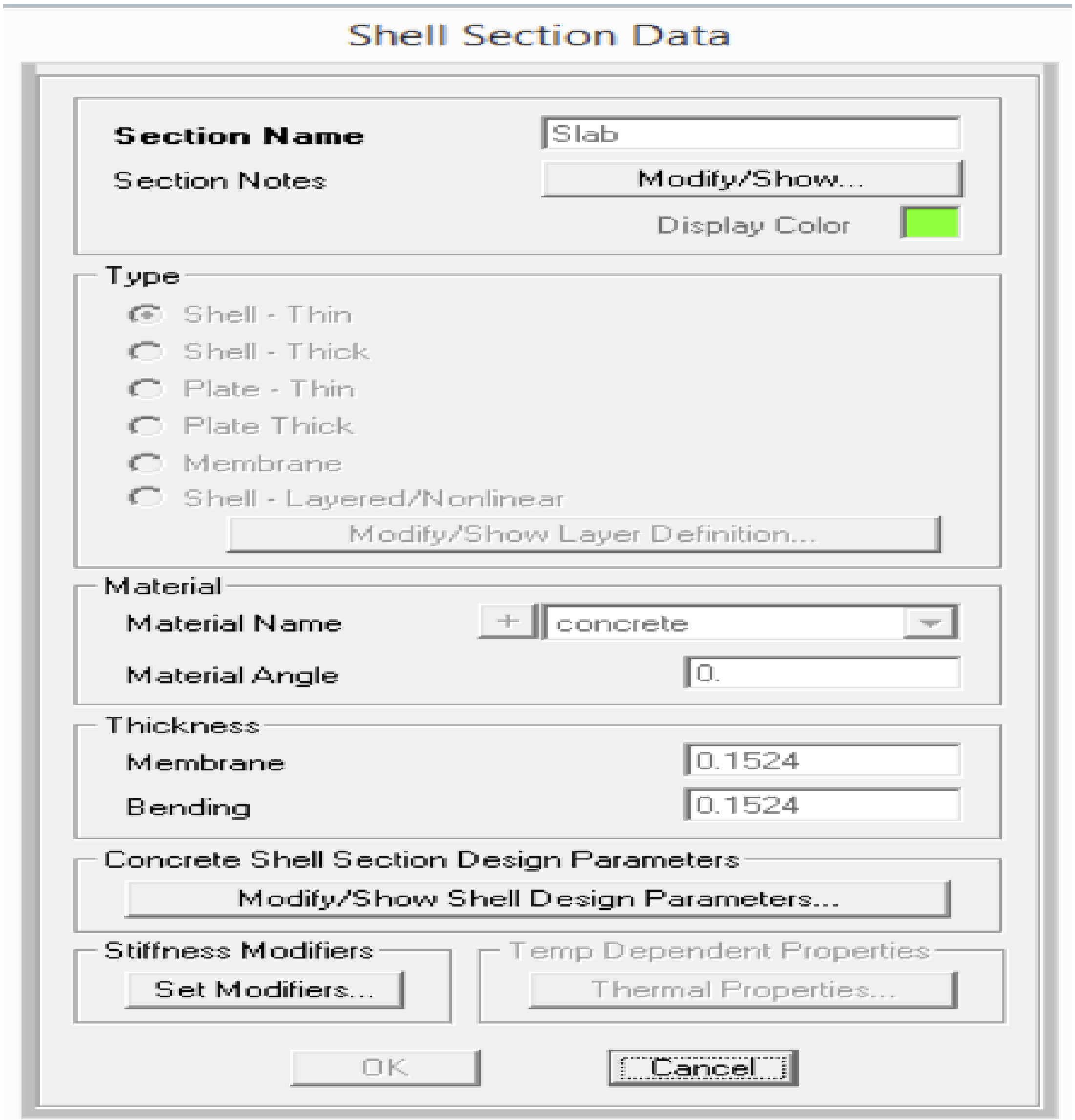


Figure 4.3: Shell section data. (SAP2000).

The results obtained from the software SAP2000 are represented as follows (Figures 4.4 to 4.7):

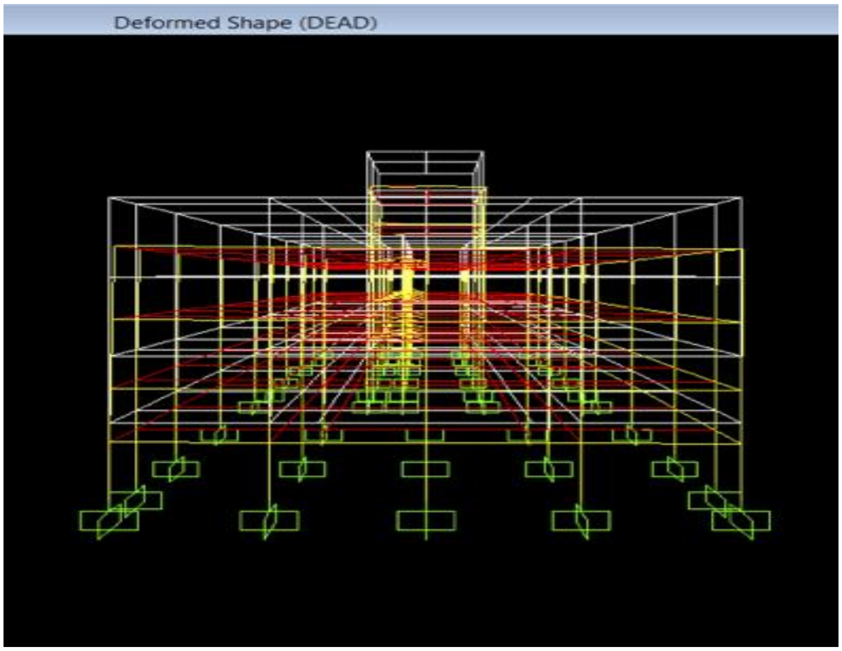


Figure 4.4: Deformation shape (SAP2000)

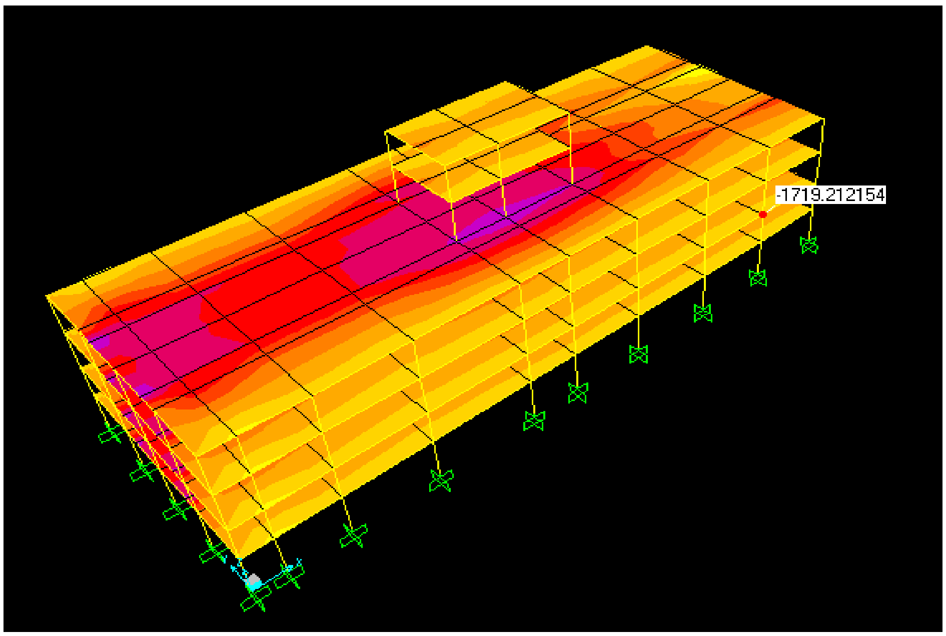


Figure 4.5: Stress in the slabs (SAP2000)

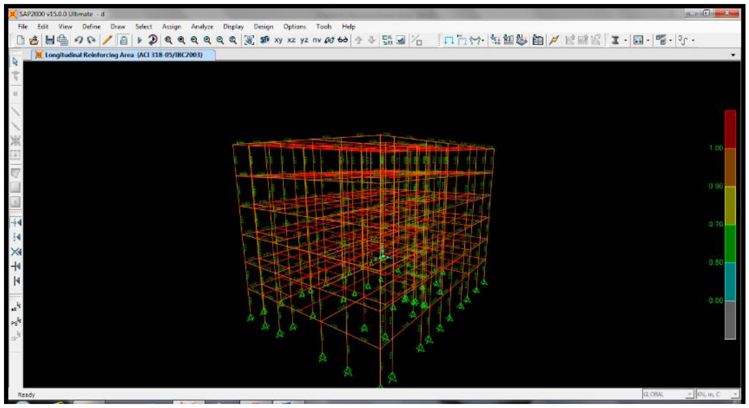


Figure 4.6: Verification of the columns (SAP2000).

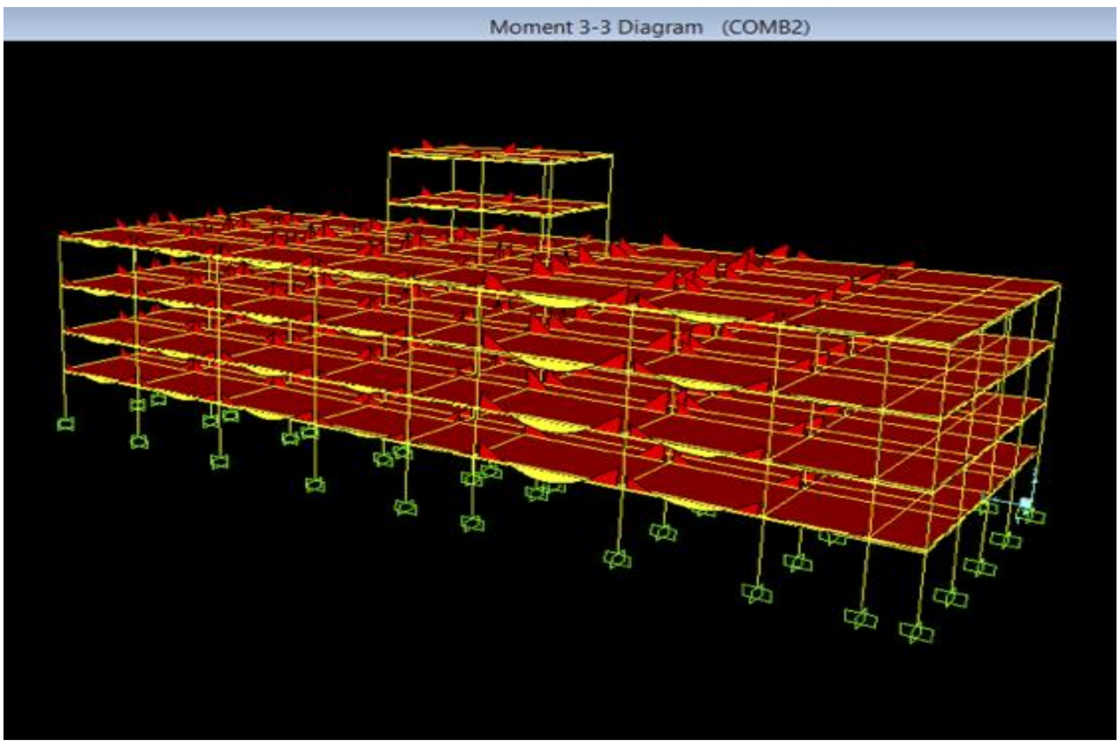


Figure 4.7: Moment in the beams (SAP2000)

Maximum deflection in beam having maximum Moment is approximately 2 which less then to leasable limit provided Saudi Building Code i.e L/240=27mm , and where the maximum moment there is a maximum deflection

4.3 Design of the restaurant

The Restaurant is a two floor (stories) structure. It is covering an area of about 1900 m^2. (i.e. 44m ×44m). The dead load on the restaurant is set automatically by the computer software SAP2000; whereas, the live load is taken to be 4 KN/m^2 and considered distributed over the area. Obviously, all the loads are transferred to the beams and then to the columns (Figure 4.8).

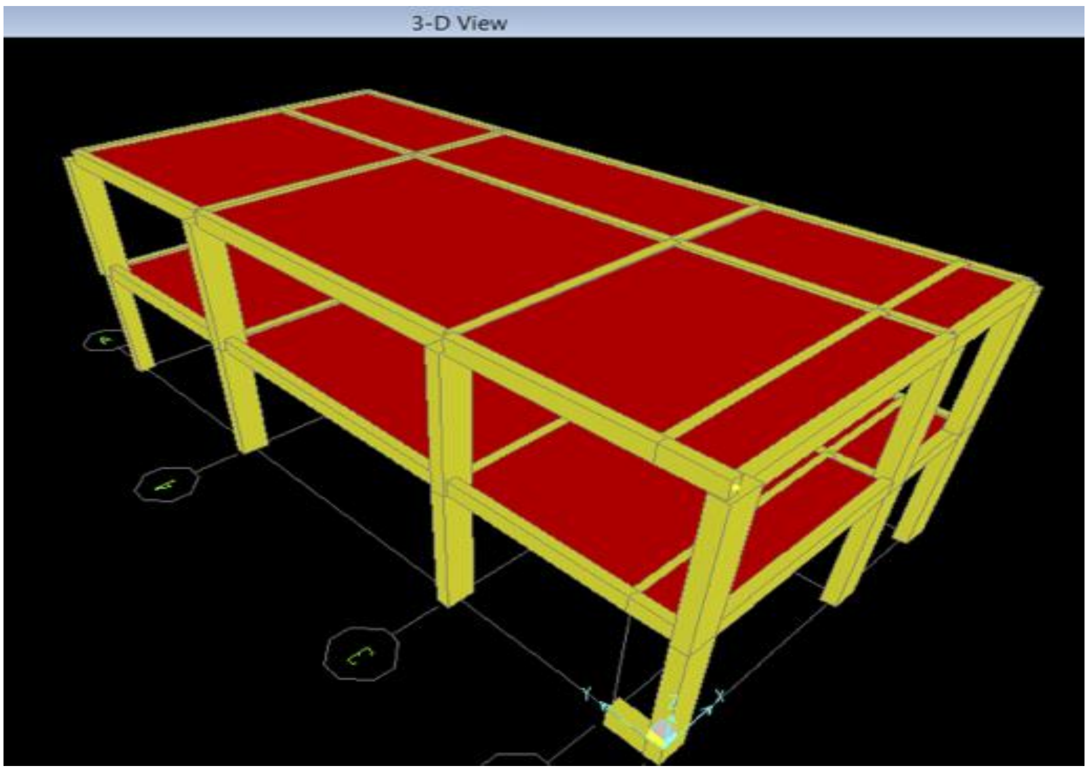


Figure 4.8: Design of restaurant (SAP2000)

Similarly to the apartment units, the columns in the ground and first floor are designed to have a cross section area of 40 cm×40 cm. They are taken to have 3 # 9 in. the longest side and 2 # 9 in. the shortest side (Figure 4.9).

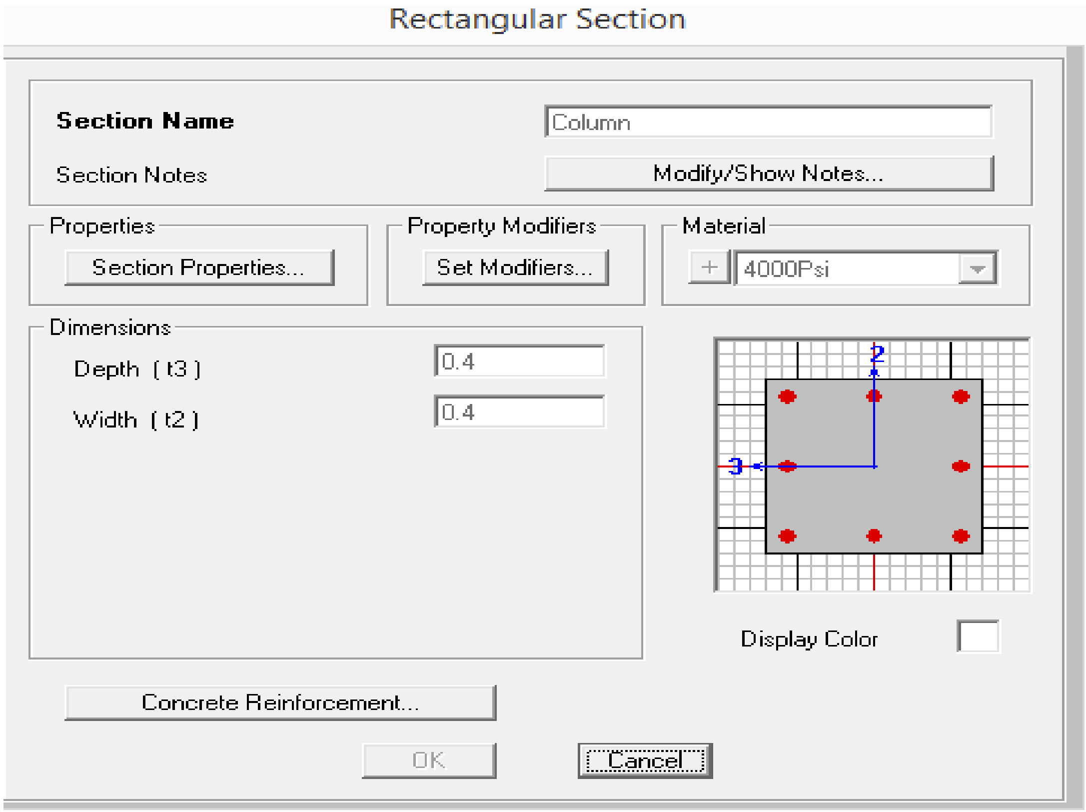


Figure 4.9: Restaurant columns design (SAP2000).

The thickness of the restaurant slabs is 25 cm and is made of a concrete corresponding to the type 4000 psi. The live load is considered to be 4 kN/m^2 distributed over the entire area (Figure 4.10).

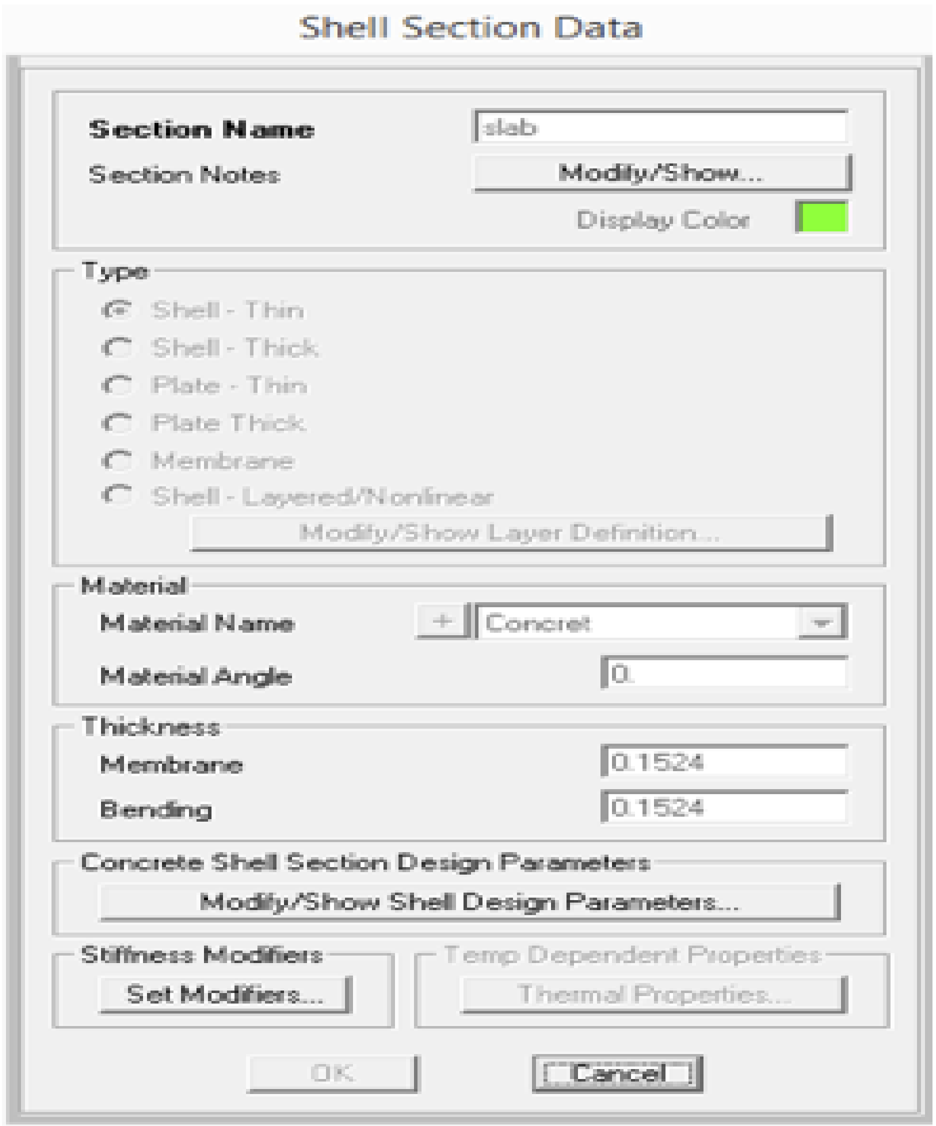


Figure 4.10: Restaurant shell section data (SAP2000).

The following figure shows the results obtained from SAP2000 corresponding to the assessment of collapse failure of the restaurant structure. It is clear from this figure (based on the orange color) that all the columns are designed with an adequate safety and cost. Moreover, it is indicated that all the beams can handle the applied loads which are safely transferred to the slabs (Figure 4.11 to 4.13).

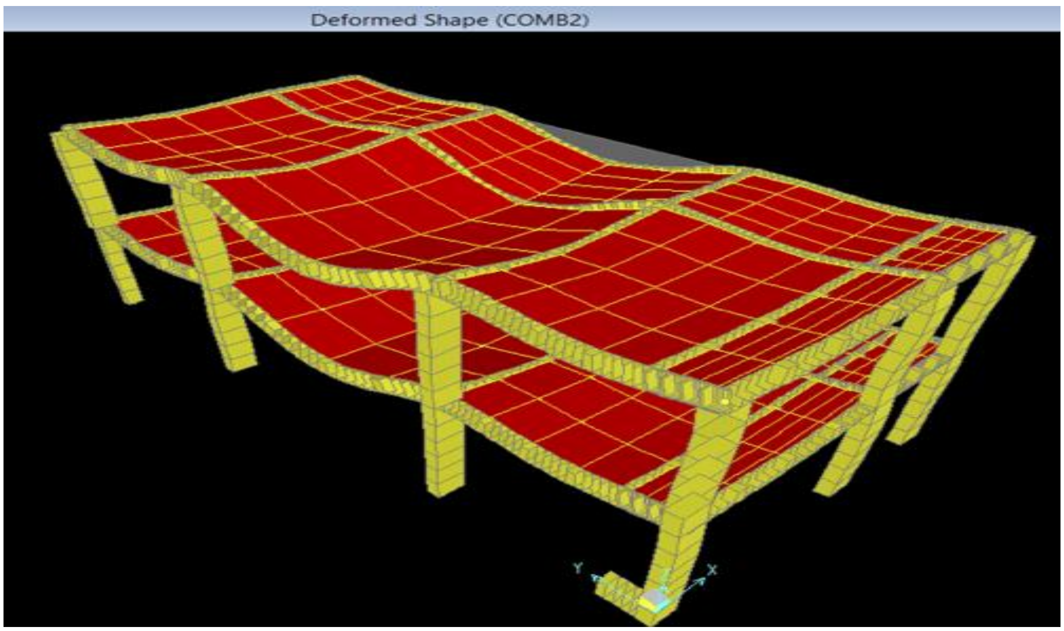


Figure 4.11: Results of deformation shape (SAP2000)

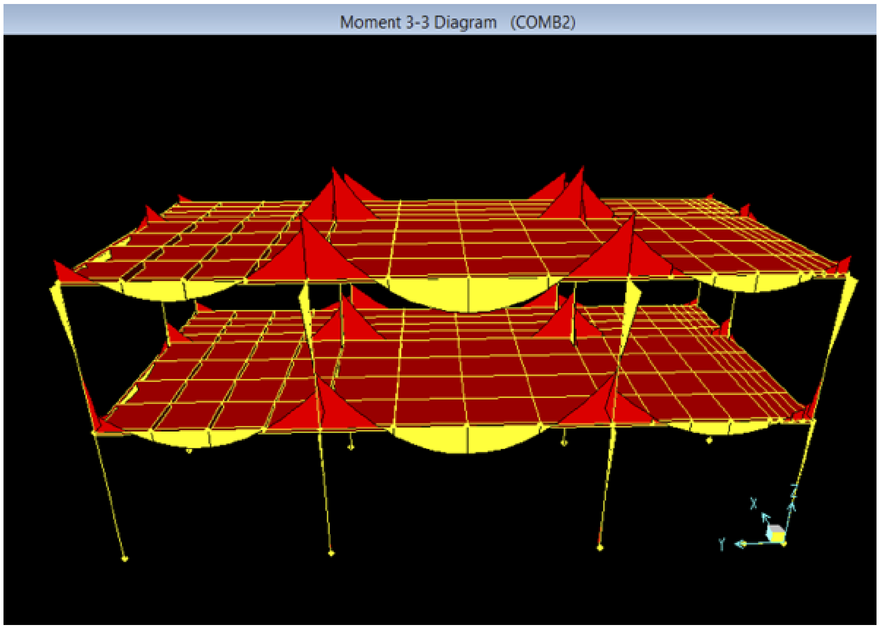


Figure 4.12: Distribution of the moment in the restaurant beams (SAP2000).

CHAPTER 5: GEOTECHNICAL DESIGN

5.1. Introduction

This chapter is concerned by the geotechnical design of the different elements of the touristic complex (i.e. apartment hotel units & restaurants) in front of a beach. In addition to proposing solutions to the two problems described previously, the design will include the selection, calculation and verification of the appropriate foundation system for the different elements of the complex. So we can summarize our outline in this chapter by:

5.2. Proposed solutions

The problems encountered in this project are summarized as follows:

1- The ground surface is at the sea level (i.e. water table located in the ground surface).
2- The state/conditions of the site (i.e. the sand is loose and saturated so susceptible to where liquefaction). Bearing in mind that soil liquefaction describes a phenomenon where by a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied earthquake stresses.

5.2.1 Solution #1 (problem #1):

In this solution the ground is elevated from the actual surface by 2.5 to 3 m (i.e. above sea level) by a controlled compacted fill. The compaction of the fill is performed on a granular soil of good quality using one of the two following methods:

1- Method of sand pumping (Figure 5.1).
2- Method of mechanical compaction (Figures 5.2 & 5.3).

Figure 5.1. Pumping Sand technology (from internet)

Figure 5.2. Mechanical compaction (photo 1, from internet)

Figure 5.3. Mechanical compaction (photo 2, from internet)

5.2.2 Solution #2 (problem #2):

As stated previously, the problem in this case is related to the phenomenon of liquefaction. Many solutions can be adapted to this problem, including:

1- Vibro-compaction using the vibroflotation technique (Figure 5.4).
2- Deep foundations, (Figure 5.5).

In case 1 of this solution, the system of foundations adopted is isolated square foundations (Figure 5.6). However, in case 2, it is recommended to use metallic driven piles.

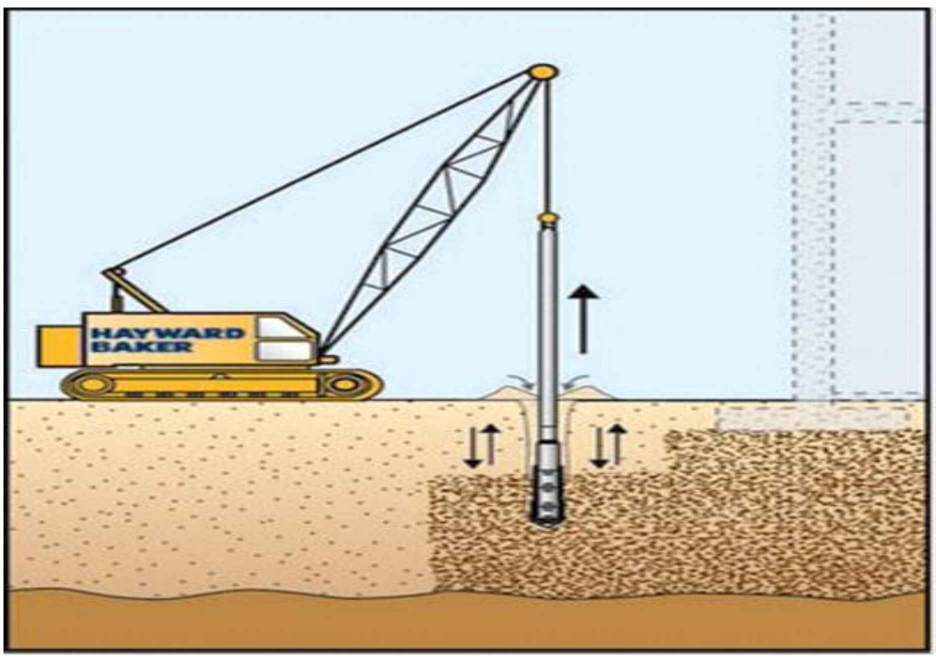


Figure 5.4 – The Concept of vibroflot compaction (from internet)

Figure 5.5. Deep foundation (driven piles, from internet)

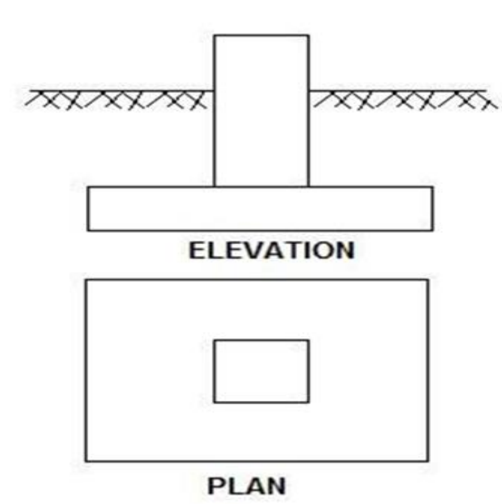


Figure 5.6. A Cross Section for isolated square foundation (from Das, 1999)

5.3. Verification of the bearing capacity

5.3.1. Isolated foundation

1- <u>Apartment hotel units:</u>

Based on the results of the SAP2000 (Chapter 4), the foundation should be designed using a load Q = 1025 kN and bending moment M = 1.65 kN.m (Figures 5.7 & 5.8). The value of this moment is very small which can be neglected. The results of the verification are grouped in Table 5.1. It is worthy to mention that:

The stress transmitted to the foundation (q_{max}) is calculated as:

$$q_{max} = Q/A + 6\times M/B^3$$

Where $A = B^2$ (Area of the foundation).

The principle of bearing capacity is verified if:

$$q_{max} \leq q_{all} \text{ (allowable stress)}$$

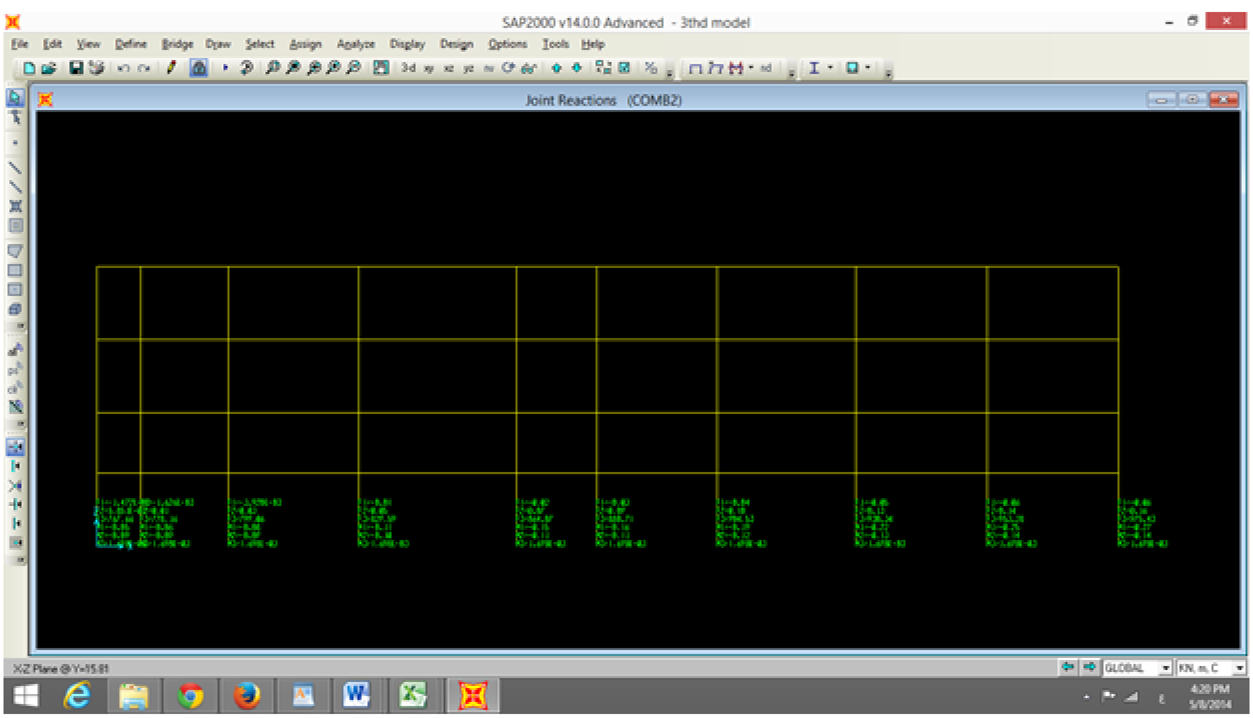


Figure 5.7. Joint reactions diagram in XZ direction (SAP200)

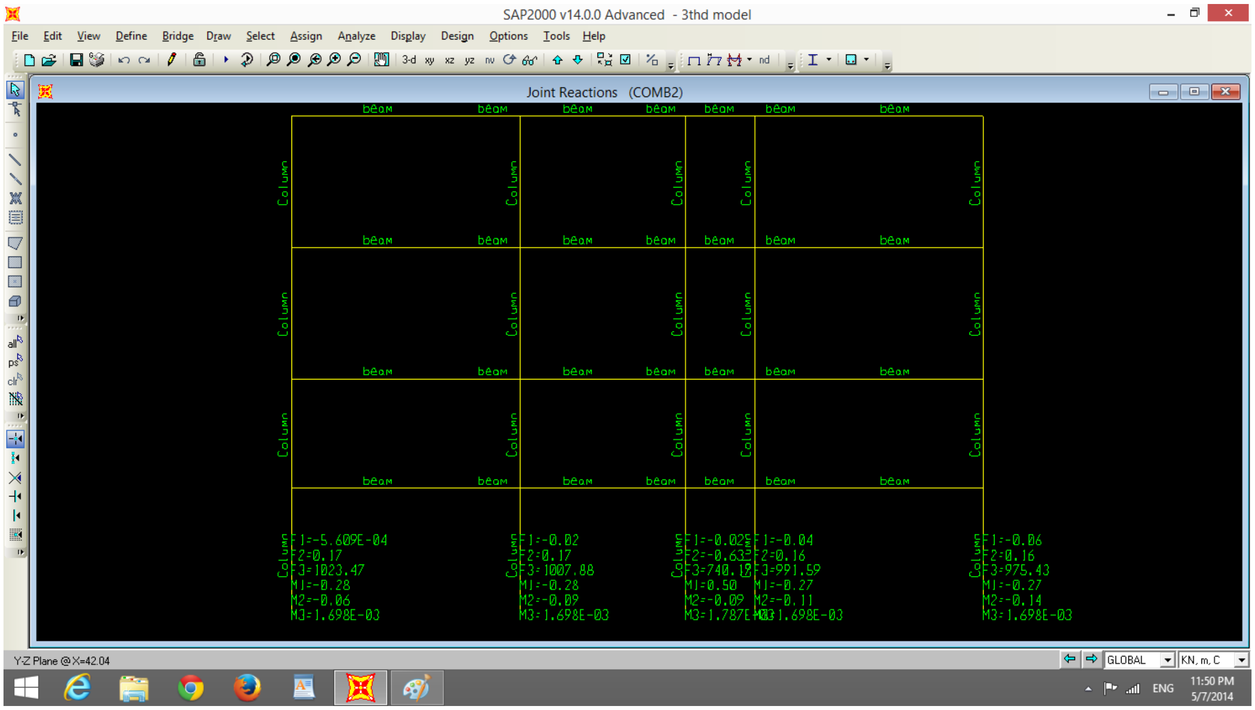


Figure 5.8. Joint reactions diagram in YZ direction (SAP2000)

N (kN)	Moment (kN.m)
1025	1.65

D (m)	B (m)	L (m)	Gama (kN/m3))	Phi (o)	c (kPa)	Nc	Nq	Ng	qu.net (kPa)	qallow (kPa)	qmax (kPa)	Results
1	1	1	10	45	0	-	134.88	271.76	2154.08	718.0266667	1034.9	FALSE
1	1.5	1.5	10	45	0	-	134.88	271.76	2561.72	853.9066667	458.4888889	OK
1	2	2	10	45	0	-	134.88	271.76	2969.36	989.7866667	257.4875	OK
1	2.5	2.5	10	45	0	-	134.88	271.76	3377	1125.666667	164.6336	OK
1.5	1	1	10	45	0	-	134.88	271.76	2823.48	941.16	1034.9	FALSE
1.5	1.5	1.5	10	45	0	-	134.88	271.76	3231.12	1077.04	458.4888889	OK
1.5	2	2	10	45	0	-	134.88	271.76	3638.76	1212.92	257.4875	OK
1.5	2.5	2.5	10	45	0	-	134.88	271.76	4046.4	1348.8	164.6336	OK
2	1	1	10	45	0	-	134.88	271.76	3492.88	1164.293333	1034.9	OK
2	1.5	1.5	10	45	0	-	134.88	271.76	3900.52	1300.173333	458.4888889	OK
2	2	2	10	45	0	-	134.88	271.76	4308.16	1436.053333	257.4875	OK
2	2.5	2.5	10	45	0	-	134.88	271.76	4715.8	1571.933333	164.6336	OK
2.5	1	1	10	45	0	-	134.88	271.76	4162.28	1387.426667	1034.9	OK
2.5	1.5	1.5	10	45	0	-	134.88	271.76	4569.92	1523.306667	458.4888889	OK
2.5	2	2	10	45	0	-	134.88	271.76	4977.56	1659.186667	257.4875	OK
2.5	2.5	2.5	10	45	0	-	134.88	271.76	5385.2	1795.066667	164.6336	OK

Table 5.1. Results of bearing capacity verification for apartment hotel units

Based on the results of Table 5.1, the following minimal dimensions were retained for the design of the foundation: D = 1.0 m and B = 1.5 m.

Where:

D = embedment depth.

B = width of the foundation.

2- Restaurants:

Similarly, based on the results of the SAP2000 (Chapter 4), the foundation should be designed using a load Q = 590 kN and a bending moment M = 9.55 kN.m (Figures 5.9 & 5.10). The value of this moment is very small due to the dimension of the units and their rigidity). It can be neglected. The results of the bearing capacity verification for such foundation are grouped in Table 5.2.

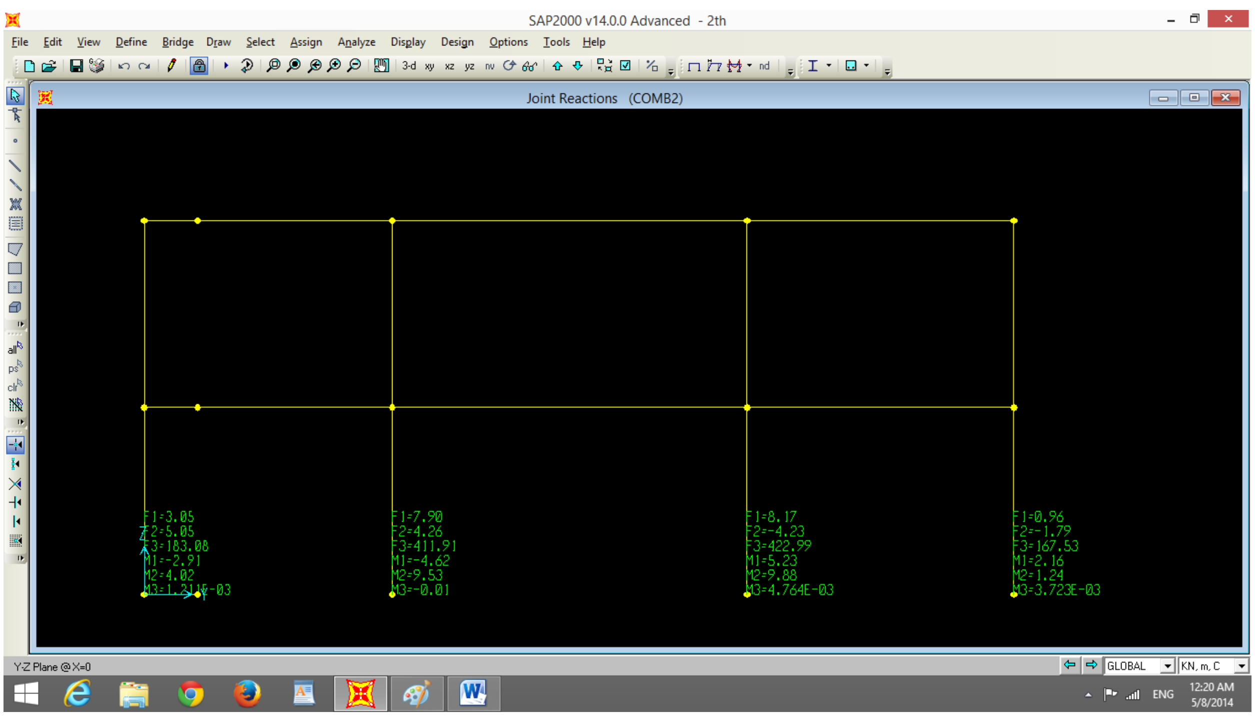


Figure 5.9. Joint reactions diagram in XZ direction (SAP2000)

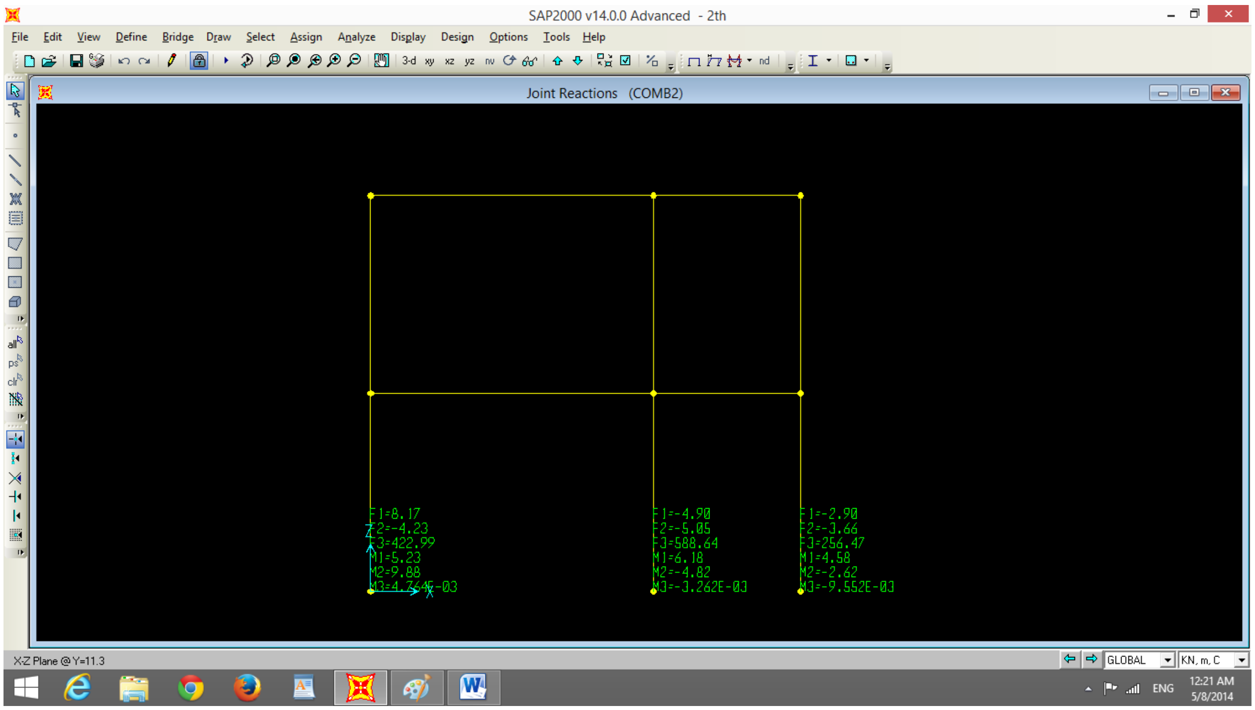


Figure 5.10. Joint reactions diagram in YZ direction (SAP2000)

N (kN)	Moment (kN.m)
590	9.55

D (m)	B (m)	L (m)	Gama (kN/m3))	Phi (o)	c (kPa)	Nc	Nq	Ng	qu.net (kPa)	qallow (kPa)	qmax (kPa)	Results
1	1	1	10	45	0	-	134.88	271.76	2154.08	718.0266667	647.3	OK
1	1.5	1.5	10	45	0	-	134.88	271.76	2561.72	853.9066667	279.2	OK
1	2	2	10	45	0	-	134.88	271.76	2969.36	989.7866667	154.6625	OK
1	2.5	2.5	10	45	0	-	134.88	271.76	3377	1125.666667	98.0672	OK
1.5	1	1	10	45	0	-	134.88	271.76	2823.48	941.16	647.3	OK
1.5	1.5	1.5	10	45	0	-	134.88	271.76	3231.12	1077.04	279.2	OK
1.5	2	2	10	45	0	-	134.88	271.76	3638.76	1212.92	154.6625	OK
1.5	2.5	2.5	10	45	0	-	134.88	271.76	4046.4	1348.8	98.0672	OK
2	1	1	10	45	0	-	134.88	271.76	3492.88	1164.293333	647.3	OK
2	1.5	1.5	10	45	0	-	134.88	271.76	3900.52	1300.173333	279.2	OK
2	2	2	10	45	0	-	134.88	271.76	4308.16	1436.053333	154.6625	OK
2	2.5	2.5	10	45	0	-	134.88	271.76	4715.8	1571.933333	98.0672	OK
2.5	1	1	10	45	0	-	134.88	271.76	4162.28	1387.426667	647.3	OK
2.5	1.5	1.5	10	45	0	-	134.88	271.76	4569.92	1523.306667	279.2	OK
2.5	2	2	10	45	0	-	134.88	271.76	4977.56	1659.186667	154.6625	OK
2.5	2.5	2.5	10	45	0	-	134.88	271.76	5385.2	1795.066667	98.0672	OK

Table 5.2 . Results of bearing capacity verification for restaurants foundations

Based on the results of Table 5.1, the following minimal dimensions were retained for the design of the foundation: D = 1.0 m and B = 1.0 m.

Where:

D = embedment depth.

B = width of the foundation.

5.3.2. Deep foundations (piles)

In this case, it is suggested to install under each column (through a cap) a driven pile (Figure 5.11). The pile will be designed to penetrate the whole depth of the liquefiable layer (i.e. to penetrate from the surface to the rock situated at 20 m depth). The total depth of each pile will be around 20 m. The numbers of piles, if any and their diameters is determined according to the principle of bearing capacity.

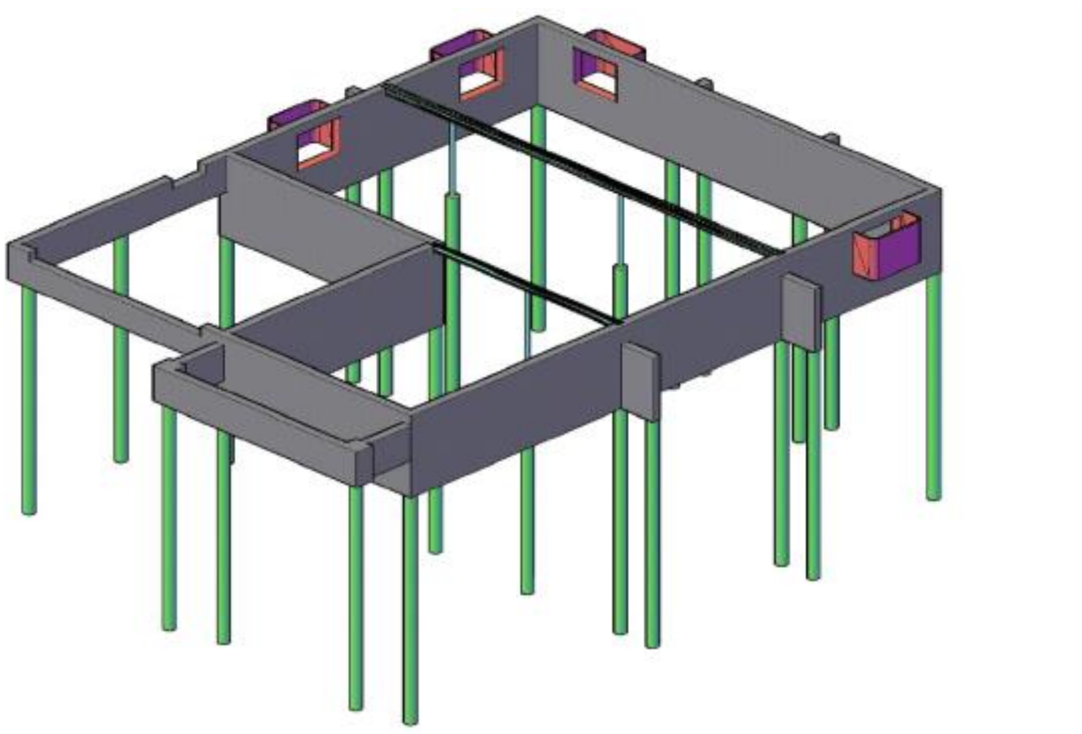


Figure 5.11. A general concept of piles raft foundation (from internet)

1- *Bearing capacity of pile of diameter B = 0.325 m :*

1- Data

			Layers' Caracteristics		
			Hi (m)	fi ou Cu (kPa)	Gamma* (KN/m3)
Loose Sand	*Layer #1*	Saturated	20	20	16
Rock	*Layer #2*		0	5000	22
			20 ← Total		

Factor Nc*	9
Factor Nq*	1
Factor of Safety, FS	3

* Estimated

2- Calculation of Pile Bearing Capacity

Method α:

i- Tip Resistance, Qp

B (m)	Ap (m2)	q (kPa)	qp (kPa)	**Qp (kN)**
0.325	0.08295523	320	45320	3759.53122

ii- Lateral resistance (Friction), Qs:

B (m)	**C (m)**	**L (m)**	**α**	**f**	**Qs (kN)**
0.325	1.0209875	20	1	20	408.395
0.325	1.0209875	0	0.25	5000	0
				ΣQs	408.395

iii- Allowable Bearing Capacity:

Qultim (kN)	Qultim.P (kN	Qadm. (kN)
4167.92622	1667.17049	1389.30874

Table 5.3. Results of bearing capacity of pile with *B* = 0.325 m

2- *Bearing capacity of pile of diameter B = 0.40 m :*

1- Data

			Layers' Caracteristics		
			Hi (m)	fi ou Cu (kPa)	Gamma* (KN/m3)
Loose Sand	*Layer #1*	Saturated	20	20	16
Rock	*Layer #2*		0	5000	22
			20 ← Total		

Factor Nc*	9
Factor Nq*	1
Factor of Safety, FS	3

* Estimated

2- Calculation of Pile Bearing Capacity

Method α:

i- Tip Resistance, Qp

B (m)	Ap (m2)	q (kPa)	qp (kPa)	**Qp (kN)**
0.4	0.12566	320	45320	5694.9112

ii- Lateral resistance (Friction), Qs:

B (m)	**C (m)**	**L (m)**	**α**	**f**	**Qs (kN)**
0.4	1.2566	20	1	20	502.64
0.4	1.2566	0	0.25	5000	0
				ΣQs	502.64

iii- Allowable Bearing Capacity:

Qultim (kN)	Qultim.P (kN	Qadm. (kN)
6197.5512	2479.02048	2065.8504

Table 5.4. Results of bearing capacity of pile with B = 0.40 m

3- ***Bearing capacity of pile of diameter B = 0.50 m :***

1- Data

Layers' Caracteristics

			Hi (m)	fi ou Cu (kPa)	Gamma* (KN/m3)
Loose Sand	*Layer #1*	Saturated	20	20	16
Rock	*Layer #2*		0	5000	22
			20 ← Total		

Factor Nc*	9
Factor Nq*	1
Factor of Safety, FS	3

* Estimated

2- Calculation of Pile Bearing Capacity

Method α:

i- Tip Resistance, Qp

B (m)	Ap (m2)	q (kPa)	qp (kPa)	**Qp (kN)**
0.5	0.19634375	320	45320	8898.29875

ii- Lateral resistance (Friction), Qs:

B (m)	**C (m)**	**L (m)**	**α**	**f**	**Qs (kN)**
0.5	1.57075	20	1	20	628.3
0.5	1.57075	0	0.25	5000	0
				ΣQs	628.3

iii- Allowable Bearing Capacity:

Qultim (kN)	Qultim.P (kN	Qadm. (kN)
9526.59875	3810.6395	3175.53292

Table 5.5. Results of bearing capacity of pile with *B* = 0.50 m

4- ***Bearing capacity of pile of diameter B = 0.60 m :***

1- Data

			Layers' Caracteristics		
			Hi (m)	fi ou Cu (kPa)	Gamma* (KN/m3)
Loose Sand	*Layer #1*	Saturated	20	20	16
Rock	*Layer #2*		0	5000	22
		Total	**20**		

Factor Nc*	9
Factor Nq*	1
Factor of Safety, FS	3

* Estimated

2- Calculation of Pile Bearing Capacity

Method α:

i- Tip Resistance, Qp

B (m)	Ap (m2)	q (kPa)	qp (kPa)	**Qp (kN)**
0.6	0.282735	320	45320	12813.5502

ii- Lateral resistance (Friction), Qs:

B (m)	**C (m)**	**L (m)**	**α**	**f**	**Qs (kN)**
0.6	1.8849	20	1	20	753.96
0.6	1.8849	0	0.25	5000	0
				ΣQs	753.96

iii- Allowable Bearing Capacity:

Qultim (kN)	Qultim.P (kN	Qadm. (kN)
13567.5102	5427.00408	4522.5034

Table 5.6. Results of bearing capacity of pile with B = 0.60 m

Based on the results summarized in Tables 5.3 to 5.6, it can be deduced that piles having diameter *B* = 325 mm is the most appropriate deep foundation for the apartments hotel units. However, for the restaurants and because the applied load on the foundation is 590 kN, which represents almost 2.5 times less the load applied on the foundation of the unit, it is suggested to use piles of diameter of *B* = 200 mm as deep foundation for the restaurants.

CHAPTER 6: CONCLUSION

6.1. Introduction

Loose sand and silt that is saturated with water can behave like a liquid when shaken by an earthquake. Earthquake waves cause water pressures to increase in the sediment and the sand grains to lose contact with each other, leading the sediment to lose strength and behave like a liquid. In general, three factors are required for liquefaction to occur: i) Loose-granular sediment, ii) Saturation of the sediment by ground water (water fills the spaces between sand and silt grains), and iii) Strong shaking. When liquefaction occurs, the ability of a soil deposit to support foundations for buildings and bridges is reduced, causing turnover (Lose of bearing capacity).

In this chapter, some relevant conclusions, drawn from this investigation, are summarized. These general conclusions are concerned by the design and repartition of the different components of the complex, the structural and geotechnical design and the prototype.

6.2. General Conclusions

The main objectives of this project are to design a series of hotel-apartments and a two floor restaurant to be constructed near to a sea beach where the soils are granular and saturated (i.e. susceptible to liquefaction). Moreover, the level of the water table in this case is almost on the surface. The project included:

- The design and repartition of the different components of the complex (such as twelve apartment hotel units, two restaurants and local roads & parking).
- Development and design of a prototype for the complex.
- Structural design of the different elements of the complex (i.e. apartment hotel unit prototype and a restaurant) using appropriate computer software, in this case SAP2000.
- Geotechnical design which include the solution proposed for the foundation systems for the different elements of the complex.

The general conclusion drawn from this project can be summarized as follows:

- A complex was developed and designed in a liquefiable soil (near to a beach). The site of the project extends over an area of about 70000 m^2. It is composed of twelve apartment units and two high class restaurant. Furthermore, many access roads and different cars parking were designed inside the habitation area.
- A prototype of the complex was developed. The prototype shows the different components of the complex, as well as, the sand area and part of the beach.
- A structural design using computer software (SAP2000) was performed, on the different components of the complex, in order to determine the appropriate reinforcements and the different solicitations transmitted to the foundations systems.
- A geotechnical investigation was carried out in order to select the appropriate solutions for the problem. Moreover, a geotechnical design was performed on the different foundation system proposed.
- Two types of foundation system were adopted for this project, including shallow foundations when the area subjected is subjected to vibro-compaction (using viboflot) and deep foundations (i.e. driven piles).

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- **Saudi Building Code** (SBC) 2007

APPINDIX A

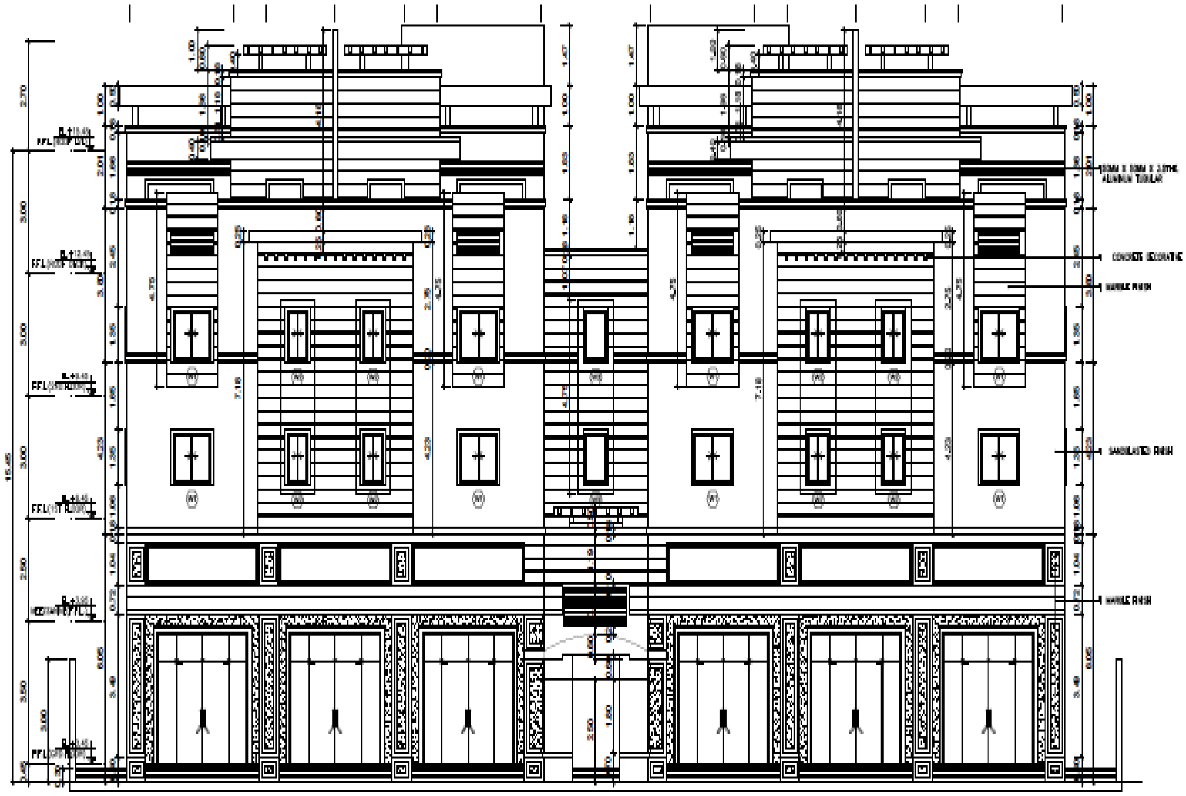


Figure A.1. Front Elevation

Figure A.2. Rear Elevation

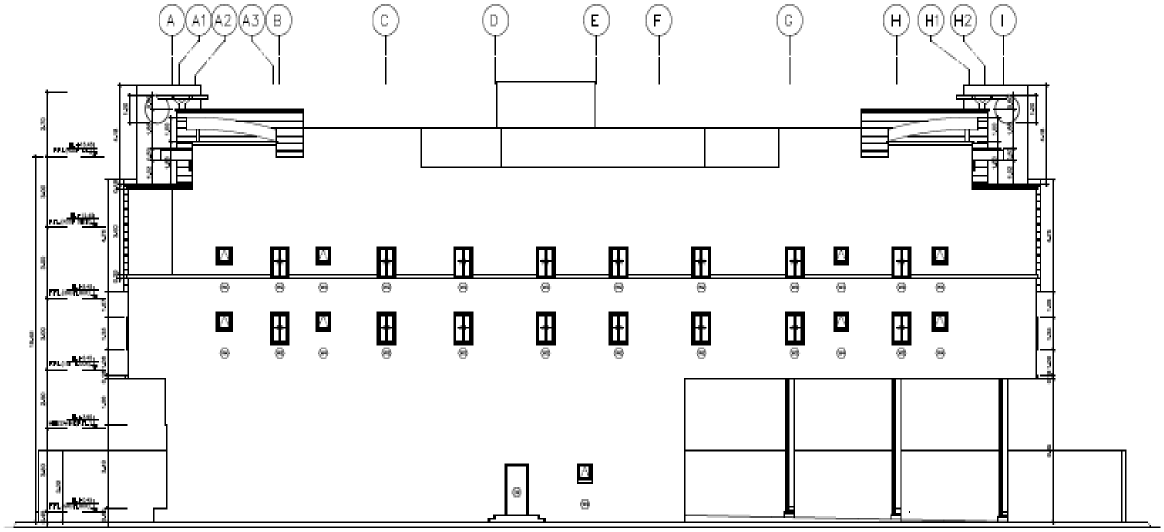


Figure A.3. Right Side Elevation

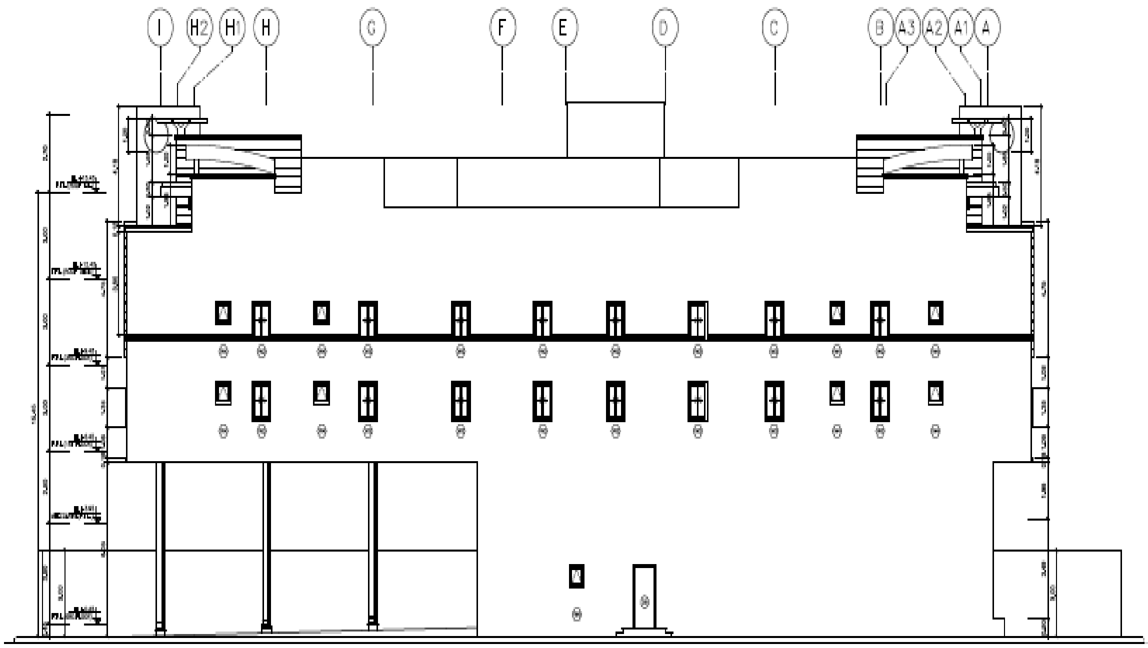


Figure A.4. Left Side Elevation

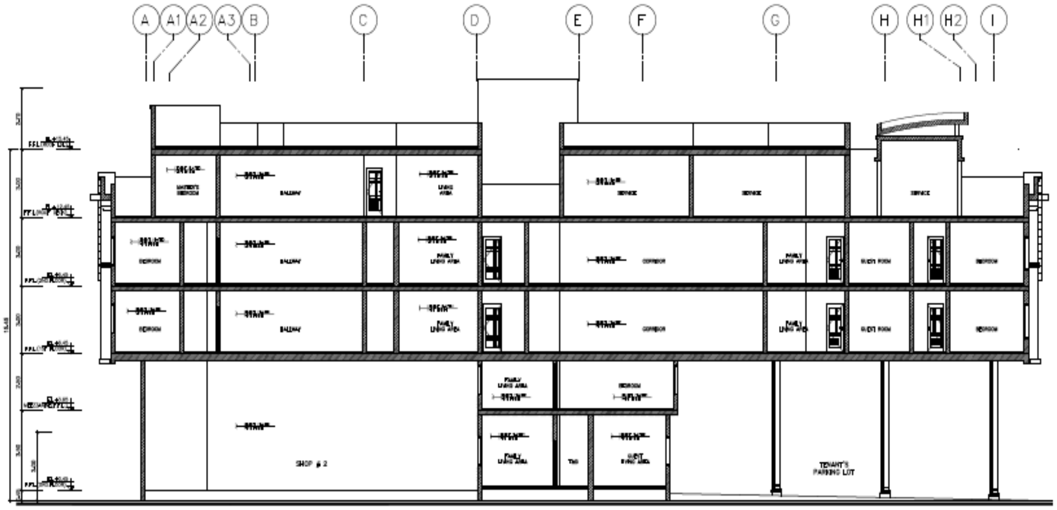


Figure A.5. Longitudinal Section A-A

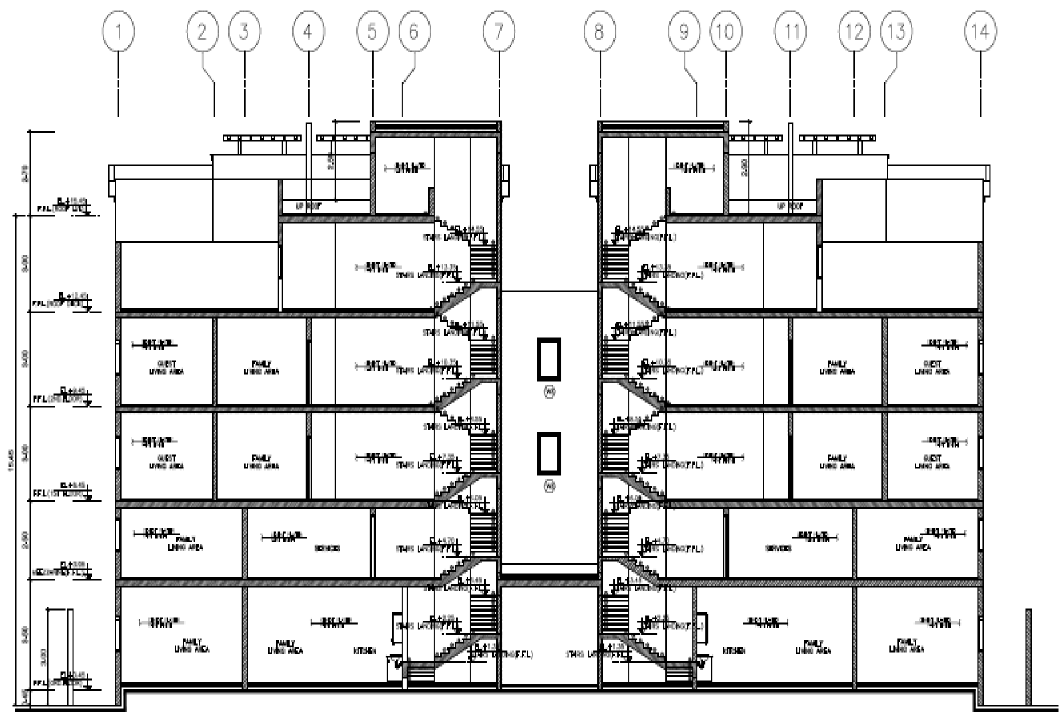


Figure A.6. Cross Section B-B

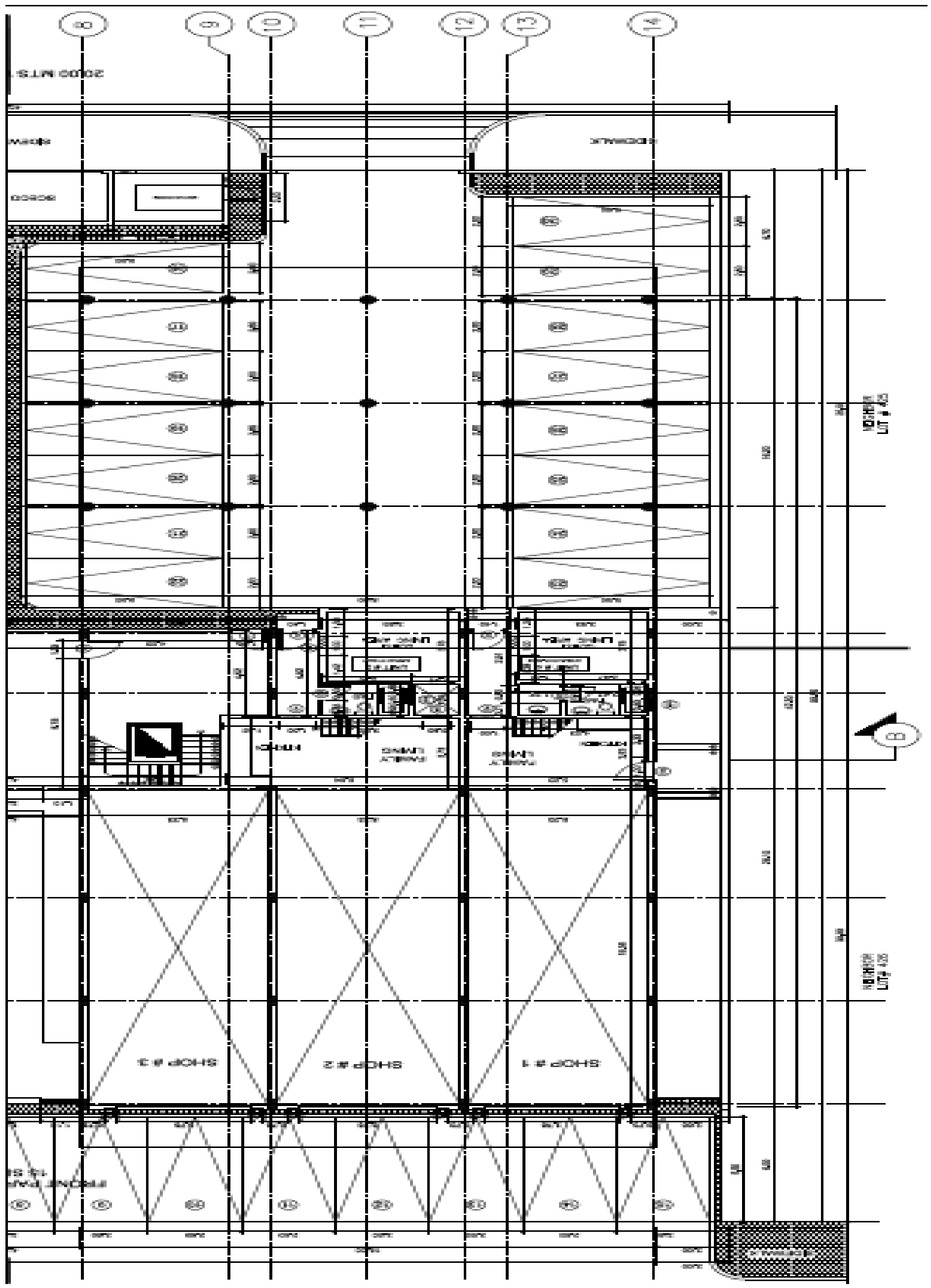


Figure A.7. Plan of Ground floor

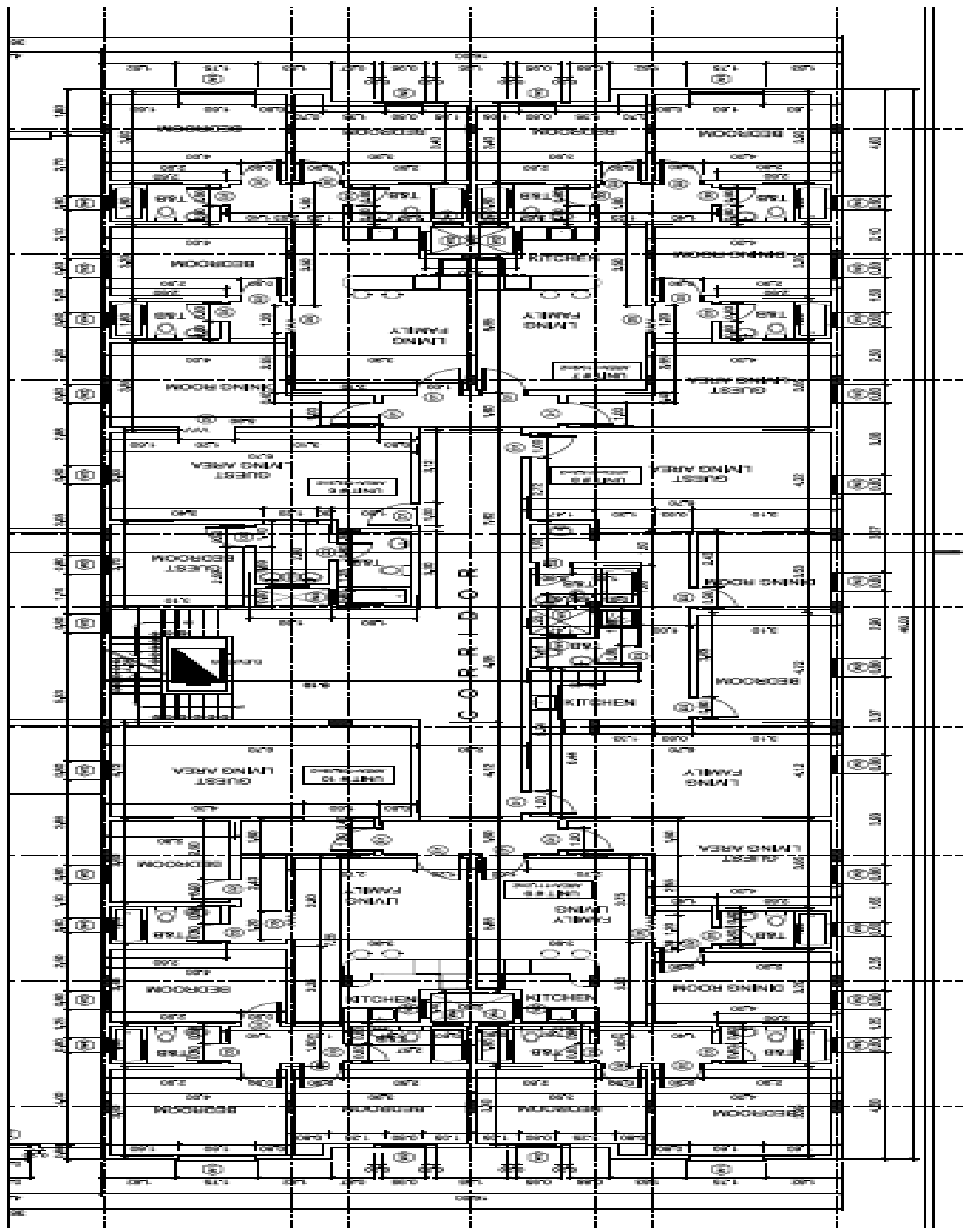


Figure A.8. Ttpical floor plan 1st and 2nd floors

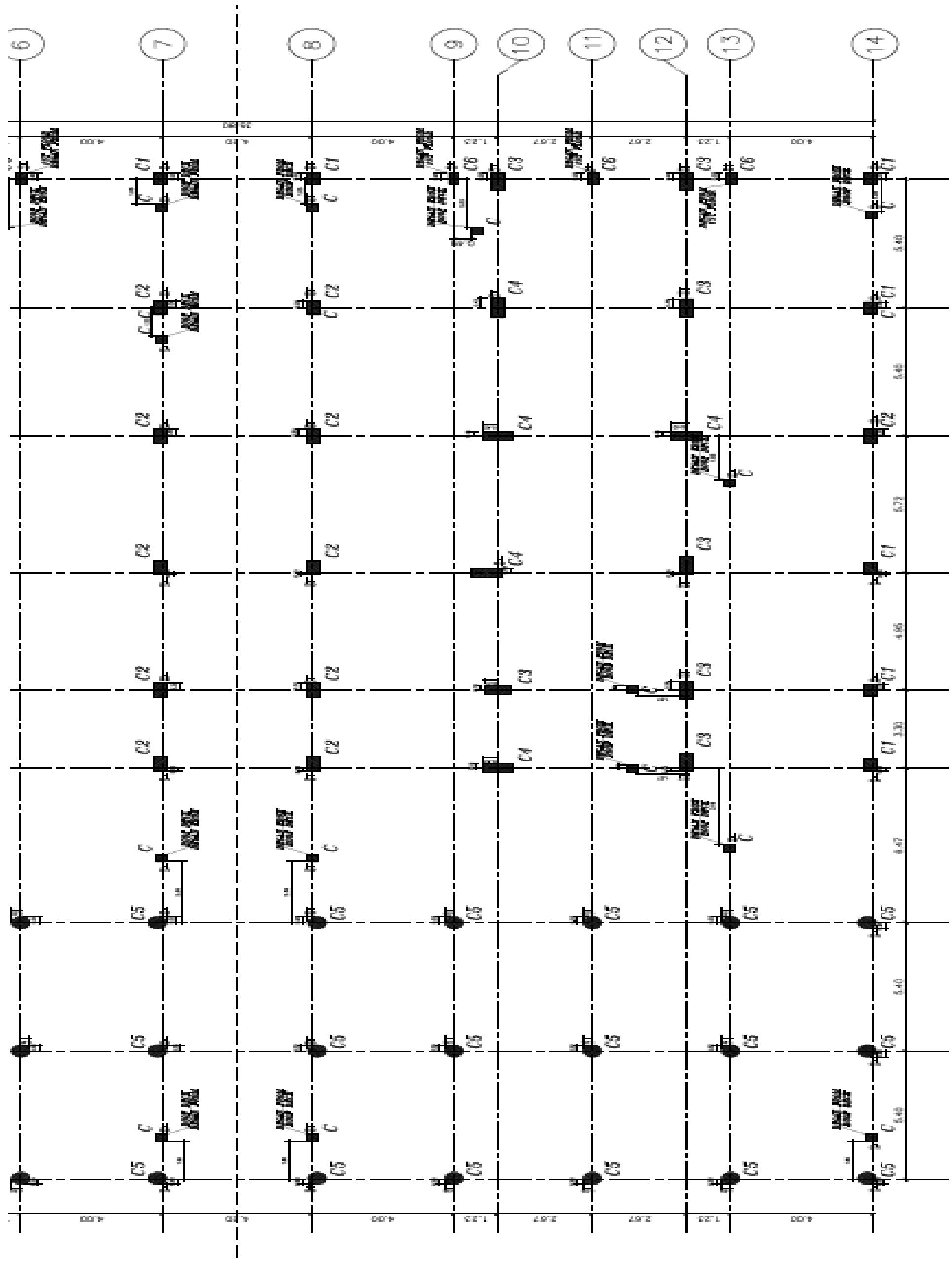


Figure A.9. Plan of the Columns Dimension

Figure A.10. 3D-View of the complex (1)

Figure A.11. 3D-View of the complex (2)

Figure A.12. 3D-View of the complex (3)

Figure A.13. 3D-View of the complex (4)

Figure A.14. 3D-View of the Restaurant (5)

Figure A.15. 3D-View of the complex (6)

Figure A.16 Prototype of The Complex (1)

Figure A.17 Prototype of The Complex (2)

Figure A.18 Prototype of The Complex (3)

Figure A.19 Prototype of The Complex (4)

Figure A.20 Prototype of The Complex (5)

APPINDIX B

Structure of the Apartment units(SAP2000)

1. Model geometry

This section provides model geometry information, including items such as joint coordinates, joint restraints, and element connectivity.

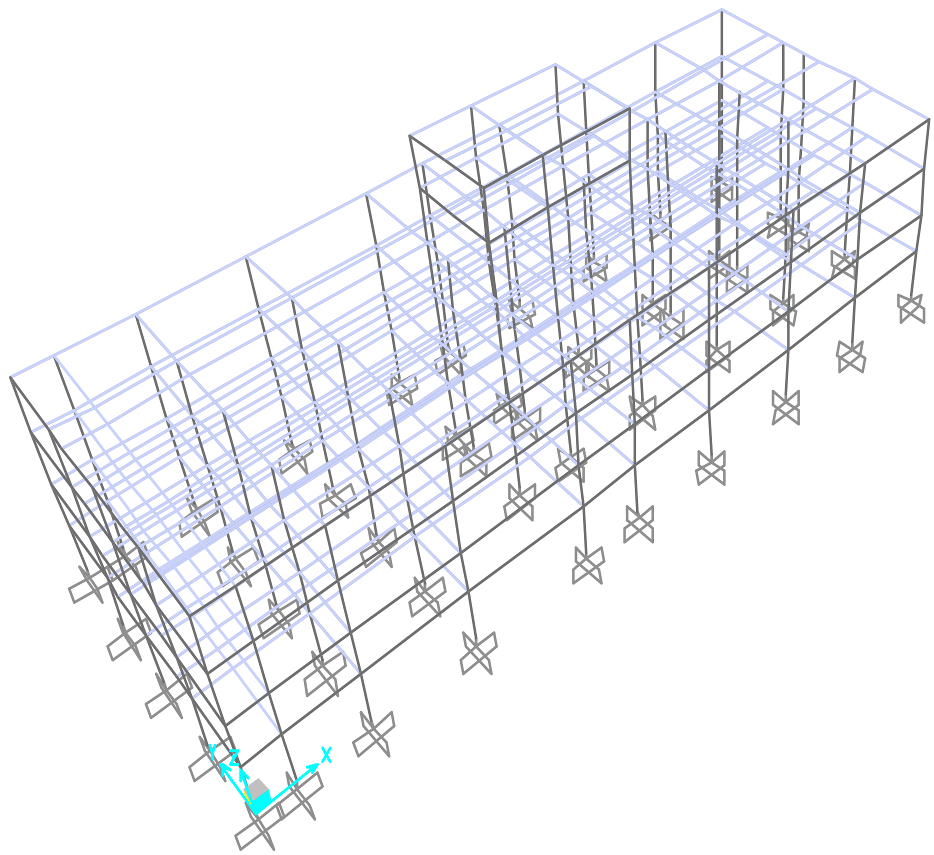


Figure B1: Finite element model

2. Material properties

This section provides material property information for materials used in the model.

Table B1: Material Properties 02 - Basic Mechanical Properties

Table B1: Material Properties 02 - Basic Mechanical Properties

Material	UnitWeight	UnitMass	E1	G12	U12	A1
	Kip/in3	Kip-s2/in4	Kip/in2	Kip/in2		1/F
4000Psi	2.3563E+01	2.4028E+00	2.5E+07	1.0E+07	0.200000	9.9000E-06

Table B1: Material Properties 02 - Basic Mechanical Properties

Material	UnitWeight	UnitMass	E1	G12	U12	A1
	Kip/in3	Kip-s2/in4	Kip/in2	Kip/in2		1/F
A615Gr60	7.6973E+01	7.8490E+00	2.0E+08			1.1700E-05
A992Fy50	7.6973E+01	7.8490E+00	2.0E+08	7.7E+07	0.300000	1.1700E-05
concrete	2.5000E+01	2.5493E+00	2.5E+13	1.0E+13	0.200000	1.1700E-05

Table B2: Material Properties 03a - Steel Data

TableB 2: Material Properties 03a - Steel Data

Material	Fy	Fu	FinalSlope
	Kip/in2	Kip/in2	
A992Fy50	344737.9	448159.3	-0.100000

Table B3: Material Properties 03b - Concrete Data

Table B3: Material Properties 03b - Concrete Data

Material	Fc	FinalSlope
	Kip/in2	
4000Psi	27579.030	-0.100000
concrete	2400.000	-0.100000

Table B4: Material Properties 03e - Rebar Data

Table B4: Material Properties 03e - Rebar Data

Material	Fy	Fu	FinalSlope
	Kip/in2	Kip/in2	
A615Gr60	413685.5	620528.2	-0.100000

3. Section properties

This section provides section property information for objects used in the model.

3.1. Frames

Table B5: Frame Section Properties 01 - General, Part 1 of 4

TableB 5: Frame Section Properties 01 - General, Part 1 of 4

SectionName	Material	Shape	t3	t2	Area	TorsConst	I33	I22
			in	in	in2	in4	in4	in4
B1	concrete	Rectangular	1.0000	0.4000	0.40	1.6E-02	3.3E-02	5.3E-03
b2	concrete	Rectangular	1.2000	0.7000	0.84	8.7E-02	0.10	3.4E-02
beam	4000Psi	Rectangular	0.4000	0.4000	0.16	3.6E-03	2.1E-03	2.1E-03
beam uniform	concrete	Rectangular	0.3000	0.3000	9.0E-02	1.1E-03	6.8E-04	6.8E-04
C1	concrete	Rectangular	0.3500	0.5000	0.18	4.1E-03	1.8E-03	3.6E-03
C2	concrete	Rectangular	0.3500	0.6000	0.21	5.5E-03	2.1E-03	6.3E-03
C3	concrete	Rectangular	0.3500	0.7500	0.26	7.6E-03	2.7E-03	1.2E-02
C4	concrete	Rectangular	0.3500	0.8500	0.30	9.0E-03	3.0E-03	1.8E-02
C5	concrete	Circle	0.5000		0.20	6.1E-03	3.1E-03	3.1E-03
Column	4000Psi	Rectangular	0.4000	0.4000	0.16	3.6E-03	2.1E-03	2.1E-03
FSEC1	concrete	Rectangular	1.4000	0.8000	1.12	0.15	0.18	6.0E-02
T1	concrete	Rectangular	0.3000	0.6000	0.18	3.7E-03	1.4E-03	5.4E-03
T3	concrete	Rectangular	0.2000	0.6000	0.12	1.3E-03	4.0E-04	3.6E-03
T4	concrete	Rectangular	0.3000	1.0000	0.30	7.3E-03	2.3E-03	2.5E-02

Table B6: Frame Section Properties 01 - General, Part 2 of 4

Table B6: Frame Section Properties 01 - General, Part 2 of 4

SectionName	AS2	AS3
	in2	in2
B1	0.33	0.33
b2	0.70	0.70
beam	0.13	0.13
beam uniform	7.5E-02	7.5E-02
C1	0.15	0.15
C2	0.18	0.18
C3	0.22	0.22
C4	0.25	0.25
C5	0.18	0.18
Column	0.13	0.13
FSEC1	0.93	0.93
T1	0.15	0.15
T3	0.10	0.10
T4	0.25	0.25

Table B7: Frame Section Properties 01 - General, Part 3 of 4

Table B7: Frame Section Properties 01 - General, Part 3 of 4

SectionName	S33	S22	Z33	Z22	R33	R22
	in3	in3	in3	in3	in	in
B1	6.7E-02	2.7E-02	0.10	4.0E-02	0.2887	0.1155
b2	0.17	9.8E-02	0.25	0.15	0.3464	0.2021
beam	1.1E-02	1.1E-02	1.6E-02	1.6E-02	0.1155	0.1155
beam uniform	4.5E-03	4.5E-03	6.8E-03	6.8E-03	0.0866	0.0866
C1	1.0E-02	1.5E-02	1.5E-02	2.2E-02	0.1010	0.1443
C2	1.2E-02	2.1E-02	1.8E-02	3.2E-02	0.1010	0.1732
C3	1.5E-02	3.3E-02	2.3E-02	4.9E-02	0.1010	0.2165
C4	1.7E-02	4.2E-02	2.6E-02	6.3E-02	0.1010	0.2454
C5	1.2E-02	1.2E-02	2.1E-02	2.1E-02	0.1250	0.1250
Column	1.1E-02	1.1E-02	1.6E-02	1.6E-02	0.1155	0.1155
FSEC1	0.26	0.15	0.39	0.22	0.4041	0.2309
T1	9.0E-03	1.8E-02	1.4E-02	2.7E-02	0.0866	0.1732
T3	4.0E-03	1.2E-02	6.0E-03	1.8E-02	0.0577	0.1732
T4	1.5E-02	5.0E-02	2.3E-02	7.5E-02	0.0866	0.2887

Table B8: Frame Section Properties 01 - General, Part 4 of 4

Table B8: Frame Section Properties 01 - General, Part 4 of 4

SectionName	AMod	A2Mod	A3Mod	JMod	I2Mod	I3Mod	MMod	WMod
B1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
b2	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
beam	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
beam uniform	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
C1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
C2	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
C3	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
C4	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
C5	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
Column	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
FSEC1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
T1	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
T3	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
T4	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

Table B9: Frame Section Properties 02 - Concrete Column, Part 1 of 3

Table B9: Frame Section Properties 02 - Concrete Column, Part 1 of 3

SectionName	RebarMatL	RebarMatC	ReinfConfig	LatReinf	Cover	NumBarsCirc	NumBars3Dir
					in		
C1	A615Gr60	A615Gr60	Rectangular	Ties	0.0400		3
C2	A615Gr60	A615Gr60	Rectangular	Ties	0.0400		3
C3	A615Gr60	A615Gr60	Rectangular	Ties	0.0400		3
C4	A615Gr60	A615Gr60	Rectangular	Ties	0.0400		3
C5	A615Gr60	A615Gr60	Circular	Ties	0.0400	8	
Column	A615Gr60	A615Gr60	Rectangular	Ties	0.0400		3

Table B10: Frame Section Properties 02 - Concrete Column, Part 2 of 3

Table B10: Frame Section Properties 02 - Concrete Column, Part 2 of 3

SectionName	NumBars2Dir
C1	3
C2	3
C3	3
C4	3
C5	
Column	3

Table B11: Frame Section Properties 02 - Concrete Column, Part 3 of 3

Table B11: Frame Section Properties 02 - Concrete Column, Part 3 of 3

SectionName	BarSizeL	BarSizeC	SpacingC	NumCBars2	NumCBars3
			in		
C1	#10	#4	0.1500	3	3
C2	#10	#4	0.1500	3	3
C3	#10	#4	0.1500	3	3
C4	#10	#4	0.1500	3	3
C5	#9	#4	0.1500		
Column	#9	#4	0.1500	3	3

Table B12: Frame Section Properties 03 - Concrete Beam, Part 1 of 2

TableB 12: Frame Section Properties 03 - Concrete Beam, Part 1 of 2

SectionName	RebarMatL	RebarMatC	TopCover	BotCover
			in	in
B1	A615Gr60	A615Gr60	0.0600	0.0600
b2	A615Gr60	A615Gr60	0.0600	0.0600
beam	A615Gr60	A615Gr60	0.0600	0.0600
beam uniform	A615Gr60	A615Gr60	0.0600	0.0600
FSEC1	A615Gr60	A615Gr60	0.0600	0.0600
T1	A615Gr60	A615Gr60	0.0600	0.0600
T3	A615Gr60	A615Gr60	0.0600	0.0600
T4	A615Gr60	A615Gr60	0.0600	0.0600

Table B13: Frame Section Properties 03 - Concrete Beam, Part 2 of 2

Table B13: Frame Section Properties 03 - Concrete Beam, Part 2 of 2

SectionName	TopLeftArea	TopRghtArea	BotLeftArea	BotRghtArea
	in2	in2	in2	in2
B1	0.0000	0.0000	0.0000	0.0000
b2	0.0000	0.0000	0.0000	0.0000
beam	0.0000	0.0000	0.0000	0.0000
beam uniform	0.0000	0.0000	0.0000	0.0000
FSEC1	0.0000	0.0000	0.0000	0.0000
T1	0.0000	0.0000	0.0000	0.0000
T3	0.0000	0.0000	0.0000	0.0000
T4	0.0000	0.0000	0.0000	0.0000

3.2. Areas

Table B14: Area Section Properties, Part 1 of 3

Table B14: Area Section Properties, Part 1 of 3

Section	Material	AreaType	Type	DrillDOF	Thickness	BendThick	F11Mod
					in	in	
Slab	concrete	Shell	Shell-Thin	Yes	0.1524	0.1524	1.000000

Table B15: Area Section Properties, Part 2 of 3

Table B15: Area Section Properties, Part 2 of 3

Section	F22Mod	F12Mod	M11Mod	M22Mod	M12Mod	V13Mod	V23Mod	MMod
Slab	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Table B16: Area Section Properties, Part 3 of 3

Table B16: Area Section Properties, Part 3 of 3

Section	WMod
Slab	1.000000

4. Load patterns

This section provides loading information as applied to the model.

4.1. Definitions

Table B17: Load Pattern Definitions

Table B17: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad
DEAD	DEAD	1.000000	
ll	LIVE	0.000000	
WL	WIND	0.000000	ASCE7-05
WL-2	WIND	0.000000	ASCE7-05
WL-3	WIND	0.000000	ASCE7-05
WL-4	WIND	0.000000	ASCE7-05
WL-5	WIND	0.000000	ASCE7-05
WL-6	WIND	0.000000	ASCE7-05
WL-7	WIND	0.000000	ASCE7-05
WL-8	WIND	0.000000	ASCE7-05
WL-9	WIND	0.000000	ASCE7-05
WL-10	WIND	0.000000	ASCE7-05

Table B17: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad
WL-11	WIND	0.000000	ASCE7-05
WL-12	WIND	0.000000	ASCE7-05

4.2. Auto wind loading

Table B18: Auto Wind - ASCE7-05, Part 1 of 2

Table B18: Auto Wind - ASCE7-05, Part 1 of 2

LoadPat	Angle	WindwardCp	LeewardCp	ASCECase	E1	E2	WindSpeed	Exposure
	Degrees						mph	
WL	0.000	0.800000	0.500000	1	0.000000	0.000000	100.00	B
WL-2	90.000	0.800000	0.500000	1	0.000000	0.000000	100.00	B
WL-3	0.000	0.800000	0.500000	2	0.150000	0.000000	100.00	B
WL-4	0.000	0.800000	0.500000	2	-0.15000	0.000000	100.00	B
WL-5	90.000	0.800000	0.500000	2	0.150000	0.000000	100.00	B
WL-6	90.000	0.800000	0.500000	2	-0.15000	0.000000	100.00	B
WL-7	0.000	0.800000	0.500000	3	0.000000	0.000000	100.00	B
WL-8	90.000	0.800000	0.500000	3	0.000000	0.000000	100.00	B
WL-9	0.000	0.800000	0.500000	4	0.150000	0.150000	100.00	B
WL-10	0.000	0.800000	0.500000	4	-0.15000	-0.15000	100.00	B
WL-11	90.000	0.800000	0.500000	4	0.150000	0.150000	100.00	B
WL-12	90.000	0.800000	0.500000	4	-0.15000	-0.15000	100.00	B

Table B19: Auto Wind - ASCE7-05, Part 2 of 2

Table B19: Auto Wind - ASCE7-05, Part 2 of 2

LoadPat	I	Kzt	GustFactor	Kd	SolidRatio
WL	1.00000	1.00000	0.850000	0.850000	
WL-2	1.00000	1.00000	0.850000	0.850000	
WL-3	1.00000	1.00000	0.850000	0.850000	
WL-4	1.00000	1.00000	0.850000	0.850000	
WL-5	1.00000	1.00000	0.850000	0.850000	
WL-6	1.00000	1.00000	0.850000	0.850000	
WL-7	1.00000	1.00000	0.850000	0.850000	
WL-8	1.00000	1.00000	0.850000	0.850000	
WL-9	1.00000	1.00000	0.850000	0.850000	
WL-10	1.00000	1.00000	0.850000	0.850000	
WL-11	1.00000	1.00000	0.850000	0.850000	
WL-12	1.00000	1.00000	0.850000	0.850000	

5. Load cases

This section provides load case information.

5.1. Definitions

Table B20: Load Case Definitions

TableB 20: Load Case Definitions

Case	Type	InitialCond	ModalCase	BaseCase
DEAD	LinStatic	Zero		
MODAL	LinModal	Zero		
ll	LinStatic	Zero		
WIND	LinStatic	Zero		
WIND-2	LinStatic	Zero		
WIND-3	LinStatic	Zero		
WIND-4	LinStatic	Zero		
WIND-5	LinStatic	Zero		
WIND-6	LinStatic	Zero		
WIND-7	LinStatic	Zero		
WIND-8	LinStatic	Zero		
WIND-9	LinStatic	Zero		
WIND-10	LinStatic	Zero		
WIND-11	LinStatic	Zero		
WIND-12	LinStatic	Zero		
WL	LinStatic	Zero		
WL-2	LinStatic	Zero		
WL-3	LinStatic	Zero		
WL-4	LinStatic	Zero		
WL-5	LinStatic	Zero		
WL-6	LinStatic	Zero		
WL-7	LinStatic	Zero		
WL-8	LinStatic	Zero		
WL-9	LinStatic	Zero		
WL-10	LinStatic	Zero		
WL-11	LinStatic	Zero		
WL-12	LinStatic	Zero		

5.2. Static case load assignments

Table B20: Case - Static 1 - Load Assignments

Table B20: Case - Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
DEAD	Load pattern	DEAD	1.000
ll	Load pattern	ll	1.000
WL	Load pattern	WL	1.000
WL-2	Load pattern	WL-2	1.000
WL-3	Load pattern	WL-3	1.000
WL-4	Load pattern	WL-4	1.000

Table B20: Case - Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
WL-5	Load pattern	WL-5	1.000
WL-6	Load pattern	WL-6	1.000
WL-7	Load pattern	WL-7	1.000
WL-8	Load pattern	WL-8	1.000
WL-9	Load pattern	WL-9	1.000
WL-10	Load pattern	WL-10	1.000
WL-11	Load pattern	WL-11	1.000
WL-12	Load pattern	WL-12	1.000

5.3. Response spectrum case load assignments

TableB 21: Function - Response Spectrum - User

Table B21: Function - Response Spectrum - User

Name	Period Sec	Accel	FuncDamp
UNIFRS	0.000	1.000	0.050
UNIFRS	1.000	1.000	

6. Load combinations

This section provides load combination information.

Table B22: Combination Definitions

Table B22: Combination Definitions

ComboName	ComboType	CaseName	ScaleFactor
COMB1	Linear Add	DEAD	1.000000
COMB1		ll	1.000000
COMB2	Linear Add	DEAD	1.200000
COMB2		ll	1.600000
1D+1.6wl	Linear Add	DEAD	1.000000
1D+1.6wl		WIND	1.600000

7. Structure results

This section provides structure results, including items such as structural periods and base reactions.

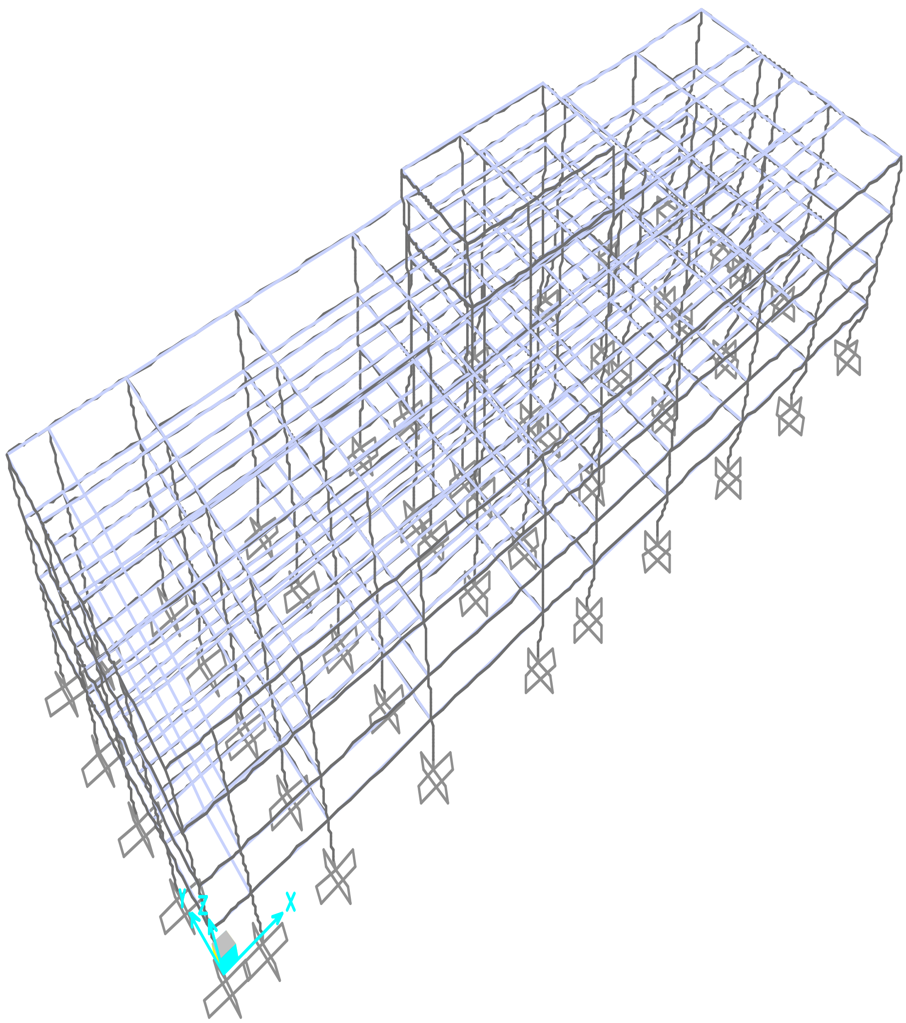
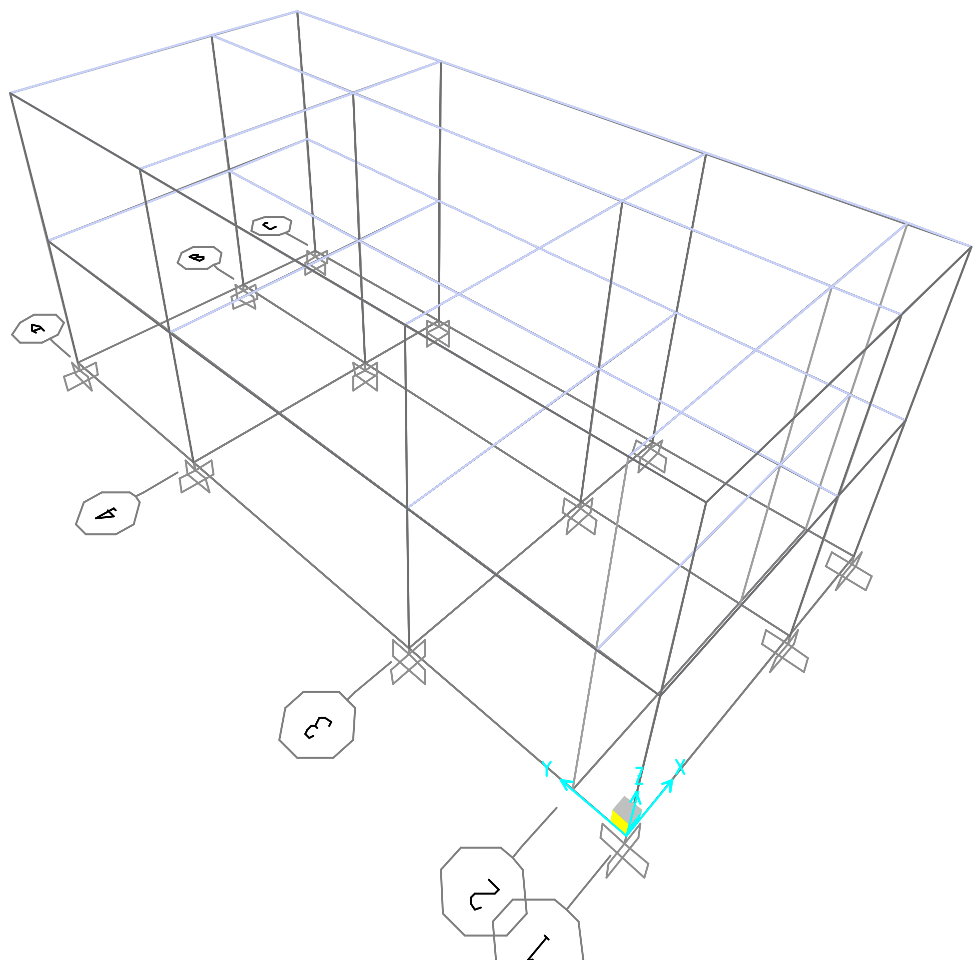


Figure B2: Deformed shape

Structure of the Restaurant(SAP2000)

1. Model geometry

This section provides model geometry information, including items such as joint coordinates, joint restraints, and element connectivity.



2. Material properties

This section provides material property information for materials used in the model.

Table B23: Material Properties 02 - Basic Mechanical Properties

Table B23: Material Properties 02 - Basic Mechanical Properties

Material	UnitWeight	UnitMass	E1	G12	U12	A1
	Tonf/m3	Tonf-s2/m4	Tonf/m2	Tonf/m2		1/C
4000Psi	2.4028E+00	2.4501E-01	2534563.56	1056068.15	0.200000	9.9000E-06
A615Gr60	7.8490E+00	8.0038E-01	20389019.16			1.1700E-05
A992Fy50	7.8490E+00	8.0038E-01	20389019.16	7841930.45	0.300000	1.1700E-05

Table B23: Material Properties 02 - Basic Mechanical Properties

Material	UnitWeight	UnitMass	E1	G12	U12	A1
	Tonf/m3	Tonf-s2/m4	Tonf/m2	Tonf/m2		1/C
Concret	2.5000E+00	2.5493E-01	20389019.16	7841930.45	0.300000	1.1700E-05

Table B24: Material Properties 03a - Steel Data, Part 1 of 2

Table B24: Material Properties 03a - Steel Data, Part 1 of 2

Material	Fy	Fu	EffFy	EffFu	SSCurveOpt	SSHysType	SHard	SMax
	Tonf/m2	Tonf/m2	Tonf/m2	Tonf/m2				
A992Fy50	35153.48	45699.53	38668.83	50269.48	Simple	Kinematic	0.015000	0.110000

Table B25: Material Properties 03a - Steel Data, Part 2 of 2

Table B25: Material Properties 03a - Steel Data, Part 2 of 2

Material	SRup	FinalSlope
A992Fy50	0.170000	-0.100000

Table B26: Material Properties 03b - Concrete Data, Part 1 of 2

Table B26: Material Properties 03b - Concrete Data, Part 1 of 2

Material	Fc	LtWtConc	SSCurveOpt	SSHysType	SFc	SCap	FinalSlope	FAngle
	Tonf/m2							Degrees
4000Psi	2812.28	No	Mander	Takeda	0.002219	0.005000	-0.100000	0.000
Concret	2109.21	No	Mander	Takeda	0.002000	0.005000	-0.100000	0.000

Table B27: Material Properties 03b - Concrete Data, Part 2 of 2

Table B27: Material Properties 03b - Concrete Data, Part 2 of 2

Material	DAngle
	Degrees
4000Psi	0.000
Concret	0.000

Table B28: Material Properties 03e - Rebar Data, Part 1 of 2

Table B28: Material Properties 03e - Rebar Data, Part 1 of 2

Material	Fy	Fu	EffFy	EffFu	SSCurveOpt	SSHysType	SHard	SCap
	Tonf/m2	Tonf/m2	Tonf/m2	Tonf/m2				
A615Gr60	42184.18	63276.27	46402.60	69603.89	Simple	Kinematic	0.010000	0.090000

Table B29: Material Properties 03e - Rebar Data, Part 2 of 2

Table B29: Material Properties 03e - Rebar Data, Part 2 of 2

Material	FinalSlope	UseCTDef
A615Gr60	-0.100000	No

3. Section properties

This section provides section property information for objects used in the model.

3.1. Frames

Table B30: Frame Section Properties 01 - General, Part 1 of 6

Table B30: Frame Section Properties 01 - General, Part 1 of 6

SectionName	Material	Shape	t3	t2	tf	tw
			m	m	m	m
Beam	Concret	Rectangular	0.400000	0.200000		
Colmun	Concret	Rectangular	0.600000	0.300000		
FSEC1	A992Fy50	I/Wide Flange	0.304800	0.127000	0.009652	0.006350
Tie Beam	Concret	Rectangular	0.600000	0.300000		

Table B31: Frame Section Properties 01 - General, Part 2 of 6

Table B31 Frame Section Properties 01 - General, Part 2 of 6

SectionName	t2b	tfb	Area	TorsConst	I33	I22	AS2
	m	m	m2	m4	m4	m4	m2
Beam			0.080000	0.000732	0.001067	0.000267	0.066667
Colmun			0.180000	0.003708	0.005400	0.001350	0.150000
FSEC1	0.127000	0.009652	0.004265	9.651E-08	0.000066	3.301E-06	0.001935
Tie Beam			0.180000	0.003708	0.005400	0.001350	0.150000

Table B32: Frame Section Properties 01 - General, Part 3 of 6

Table B32: Frame Section Properties 01 - General, Part 3 of 6

SectionName	AS3	S33	S22	Z33	Z22	R33	R22
	m2	m3	m3	m3	m3	m	m
Beam	0.066667	0.005333	0.002667	0.008000	0.004000	0.115470	0.057735
Colmun	0.150000	0.018000	0.009000	0.027000	0.013500	0.173205	0.086603
FSEC1	0.002043	0.000431	0.000052	0.000491	0.000081	0.124145	0.027823
Tie Beam	0.150000	0.018000	0.009000	0.027000	0.013500	0.173205	0.086603

Table B33: Frame Section Properties 01 - General, Part 4 of 6

Table B33: Frame Section Properties 01 - General, Part 4 of 6

SectionName	ConcCol	ConcBeam	Color	TotalWt	TotalMass	FromFile	AMod
				Tonf	Tonf-s2/m		
Beam	No	Yes	Green	35.4600	3.62	No	1.000000
Colmun	Yes	No	Red	36.2250	3.69	No	1.000000

SectionName	ConcCol	ConcBeam	Color	TotalWt	TotalMass	FromFile	AMod
				Tonf	Tonf-s2/m		
FSEC1	No	No	Magenta	0.0000	0.00	No	1.000000
Tie Beam	No	Yes	Gray8Dark	0.4500	4.589E-02	No	1.000000

Table B34: Frame Section Properties 01 - General, Part 5 of 6

Table B34: Frame Section Properties 01 - General, Part 5 of 6

SectionName	A2Mod	A3Mod	JMod	I2Mod	I3Mod	MMod	WMod
Beam	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Colmun	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
FSEC1	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Tie Beam	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Table B35: Frame Section Properties 01 - General, Part 6 of 6

Table B35: Frame Section Properties 01 - General, Part 6 of 6

SectionName	GUID	Notes
Beam		Added 4/20/2014 10:54:43 AM
Colmun		Added 4/20/2014 10:55:38 AM
FSEC1		Added 4/20/2014 10:52:46 AM
Tie Beam		Added 4/20/2014 10:53:47 AM

Table B36: Frame Section Properties 02 - Concrete Column, Part 1 of 2

Table B36: Frame Section Properties 02 - Concrete Column, Part 1 of 2

SectionName	RebarMatL	RebarMatC	ReinfConfig	LatReinf	Cover	NumBars3Dir	NumBars2Dir	BarSizeL
					m			
Colmun	A615Gr60	A615Gr60	Rectangular	Ties	0.040000	3	3	#9

Table B37: Frame Section Properties 02 - Concrete Column, Part 2 of 2

Table B37: Frame Section Properties 02 - Concrete Column, Part 2 of 2

SectionName	BarSizeC	SpacingC	NumCBars2	NumCBars3	ReinfType
		m			
Colmun	#4	0.150000	3	3	Design

Table B38: Frame Section Properties 03 - Concrete Beam

Table B38: Frame Section Properties 03 - Concrete Beam

SectionName	RebarMatL	RebarMatC	TopCover	BotCover	TopLeftArea	TopRghtArea	BotLeftArea	BotRghtArea
			m	m	m2	m2	m2	m2
Beam	A615Gr60	A615Gr60	0.060000	0.060000	0.000000	0.000000	0.000000	0.000000
Tie Beam	A615Gr60	A615Gr60	0.060000	0.060000	0.000000	0.000000	0.000000	0.000000

3.2. Areas

Table B39: Area Section Properties, Part 1 of 4

Table B39: Area Section Properties, Part 1 of 4

Section	Material	MatAngle	AreaType	Type	DrillDOF	Thickness	BendThick	Arc
		Degrees				m	m	Degrees
slab	Concrete	0.000	Shell	Shell-Thin	Yes	0.152400	0.152400	

Table B40: Area Section Properties, Part 2 of 4

Table B40: Area Section Properties, Part 2 of 4

Section	InComp	CoordSys	Color	TotalWt	TotalMass	F11Mod	F22Mod
				Tonf	Tonf-s2/m		
slab			Green	94.3966	9.63	1.000000	1.000000

Table B41: Area Section Properties, Part 3 of 4

Table B41: Area Section Properties, Part 3 of 4

Section	F12Mod	M11Mod	M22Mod	M12Mod	V13Mod	V23Mod	MMod	WMod
slab	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Table B42: Area Section Properties, Part 4 of 4

Table B42: Area Section Properties, Part 4 of 4

Section	GUID	Notes
slab		Added 4/20/2014 11:03:13 AM

4. Load patterns

This section provides loading information as applied to the model.

4.1. Definitions

Table B43: Load Pattern Definitions

Table B43: Load Pattern Definitions

LoadPat	DesignType	SelfWtMult	AutoLoad	GUID	Notes
DEAD	DEAD	1.000000			
Live	LIVE	0.000000			

5. Load cases

This section provides load case information.

5.1. Definitions

Table B44: Load Case Definitions, Part 1 of 2

Table B44: Load Case Definitions, Part 1 of 2

Case	Type	InitialCond	ModalCase	BaseCase	DesTypeOpt	DesignType	AutoType
DEAD	LinStatic	Zero			Prog Det	DEAD	None
MODAL	LinModal	Zero			Prog Det	OTHER	None
Live	LinStatic	Zero			Prog Det	LIVE	None

Table B45: Load Case Definitions, Part 2 of 2

Table B45: Load Case Definitions, Part 2 of 2

Case	RunCase	CaseStatus	GUID	Notes
DEAD	Yes	Finished		
MODAL	No	Not Run		
Live	Yes	Finished		

5.2. Static case load assignments

Table B46: Case - Static 1 - Load Assignments

Table B46: Case - Static 1 - Load Assignments

Case	LoadType	LoadName	LoadSF
DEAD	Load pattern	DEAD	1.000000
Live	Load pattern	Live	1.000000

5.3. Response spectrum case load assignments

Table B47: Function - Response Spectrum - User

Table B47: Function - Response Spectrum - User

Name	Period	Accel	FuncDamp
	Sec		
UNIFRS	0.000000	1.000000	0.050000
UNIFRS	1.000000	1.000000	

6. Load combinations

This section provides load combination information.

Table B48: Combination Definitions, Part 1 of 3

Table B48: Combination Definitions, Part 1 of 3

ComboName	ComboType	AutoDesign	CaseType	CaseName	ScaleFactor	SteelDesign
COMB1	Linear Add	No	Linear Static	DEAD	1.000000	No
COMB1			Linear Static	Live	1.000000	
COMB2	Linear Add	No	Linear Static	DEAD	1.200000	No
COMB2			Linear Static	Live	1.600000	
DCON1	Linear Add	Yes	Linear Static	DEAD	1.400000	No
DCON2	Linear Add	Yes	Linear Static	DEAD	1.200000	No
DCON2			Linear Static	Live	1.600000	

Table B49: Combination Definitions, Part 2 of 3

Table B49: Combination Definitions, Part 2 of 3

ComboName	CaseName	ConcDesign	AlumDesign	ColdDesign	GUID
COMB1	DEAD	Yes	No	No	
COMB1	Live				
COMB2	DEAD	Yes	No	No	
COMB2	Live				
DCON1	DEAD	Yes	No	No	
DCON2	DEAD	Yes	No	No	

Table B49: Combination Definitions, Part 2 of 3

ComboName	CaseName	ConcDesign	AlumDesign	ColdDesign	GUID
DCON2	Live				

Table B50: Combination Definitions, Part 3 of 3

Table B50: Combination Definitions, Part 3 of 3

ComboName	CaseName	Notes
COMB1	DEAD	
COMB1	Live	
COMB2	DEAD	
COMB2	Live	
DCON1	DEAD	Dead Only; Strength
DCON2	DEAD	Dead + Live; Strength
DCON2	Live	

7. Structure results

This section provides structure results, including items such as structural periods and base reactions.

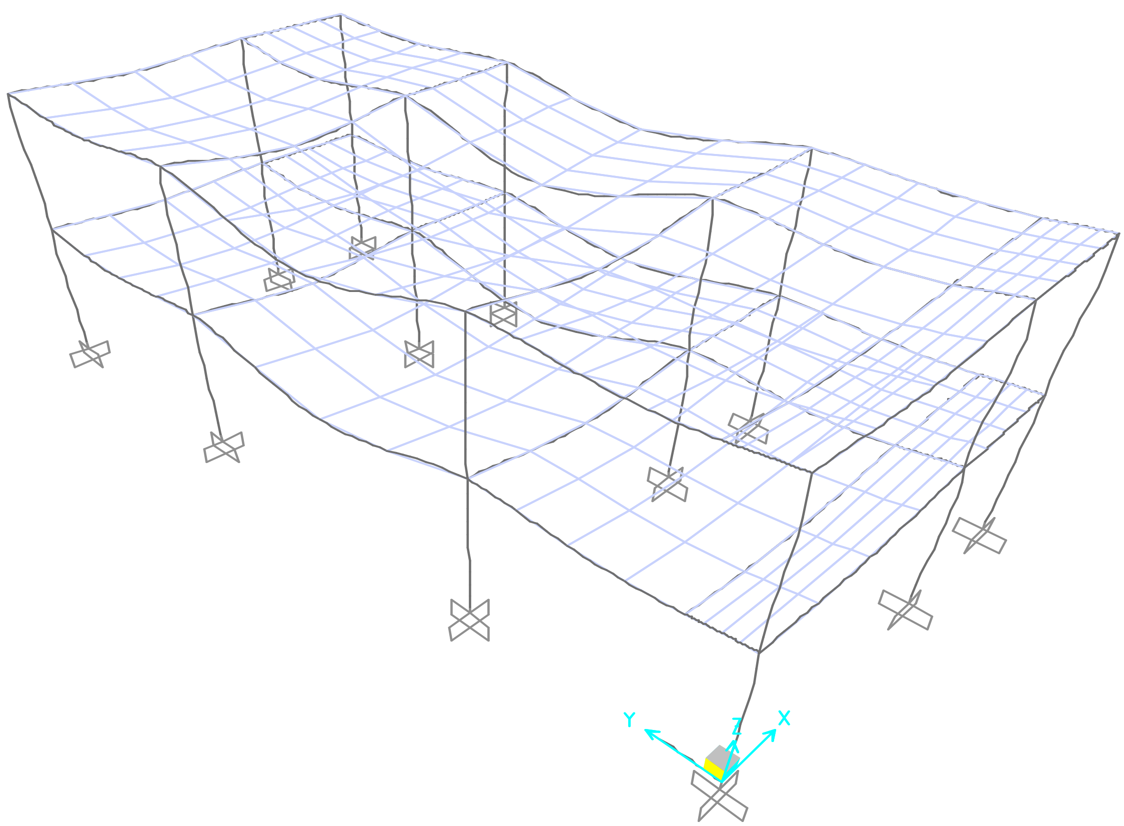


Figure B2: Deformed shape